How to Choose a Cell Size?

Stephen Hundt

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What do we consider?

How does grid size affect the precision & accuracy of outputs identified in our model objectives?

- Resolution of input and calibration data
- Solution Accuracy
- Process Representation

Do long runtimes restrict parameterization, calibration, & uncertainty analysis?

- Runtime

Are we inviting misuse?

- Implied precision of model

Is it practical to change model to fit new purposes?

- Flexibility for future uses

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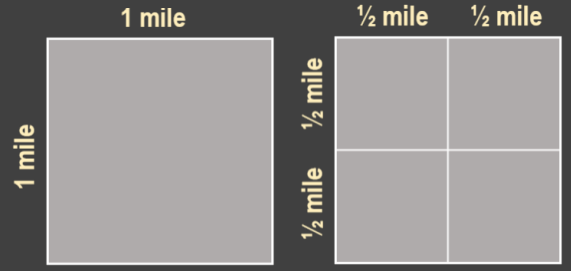
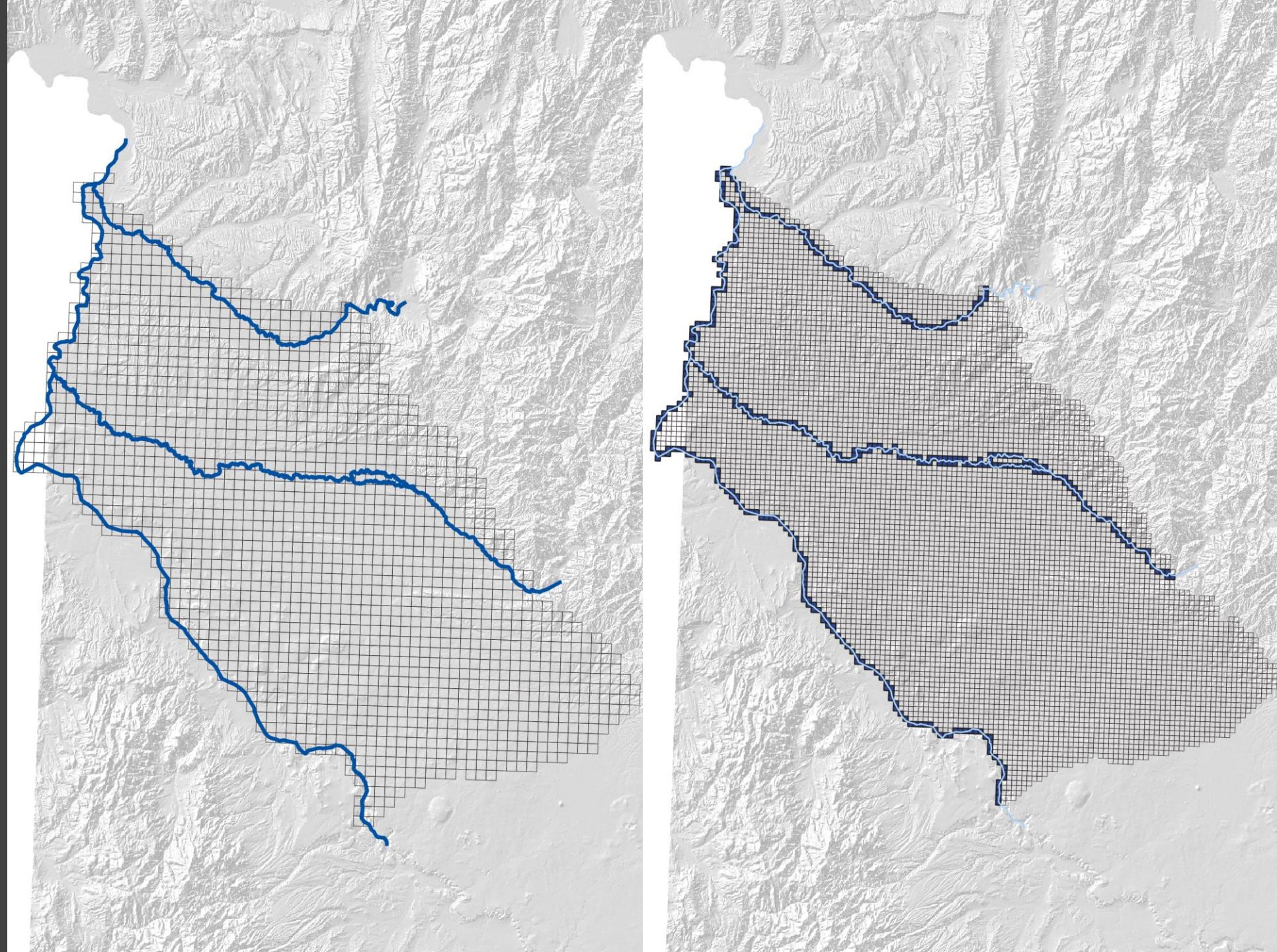
Context



	1 mi	½ mi
Cell size (square miles)	1	0.25
Cell size (acres)	640	160

Cells in Layer 1	1,857	7,351
Cells in Layer 2	788	3,113
Cells in Layer 3	1,356	5,229
Cells in Layer 4	1,747	6,908
Cells in Layer 5	1,504	5,911
Total Cells	**7,252**	**28,482**



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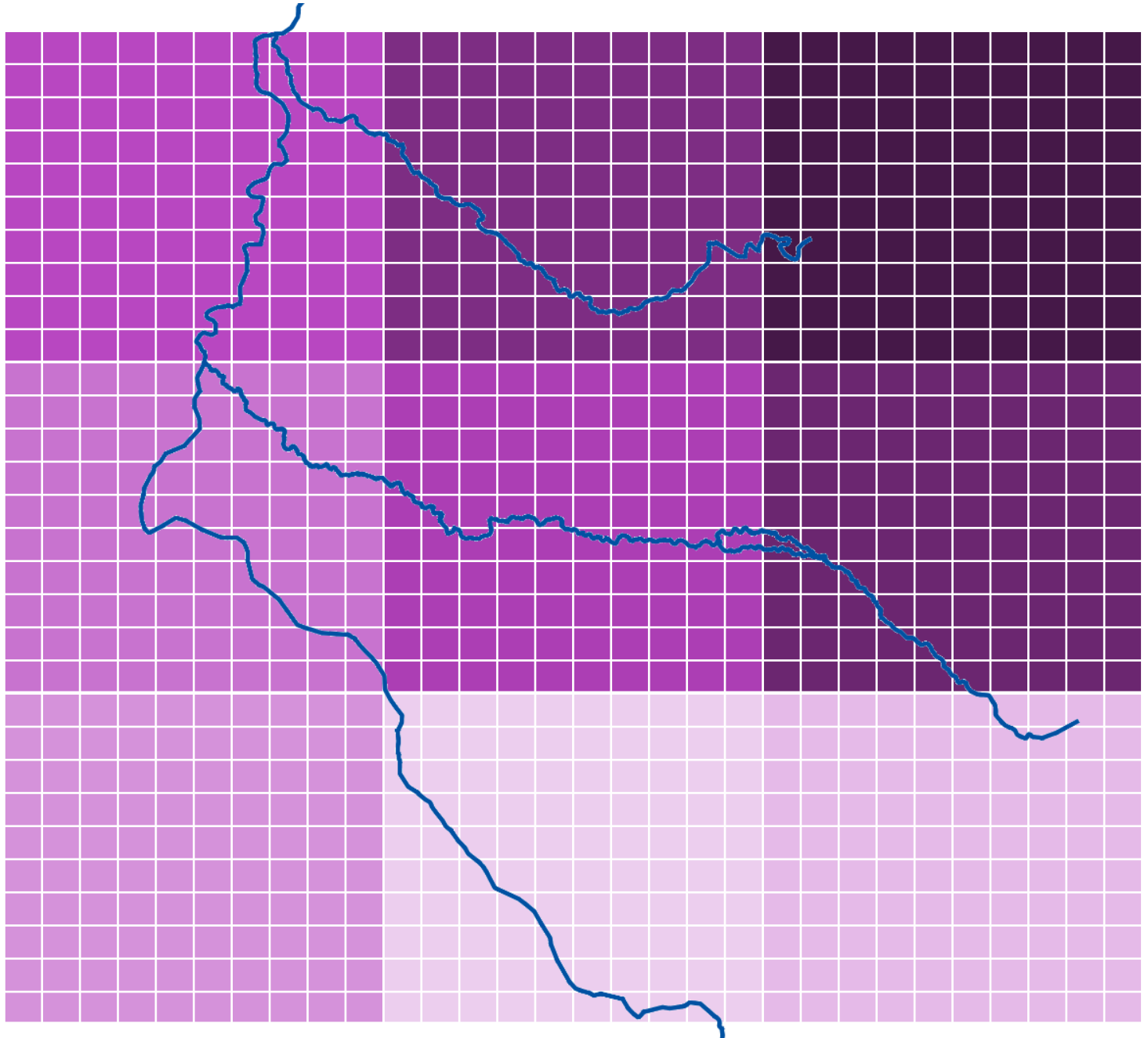
Data Resolution

Data Resolution

"Model is no better than the data you have to put into it."



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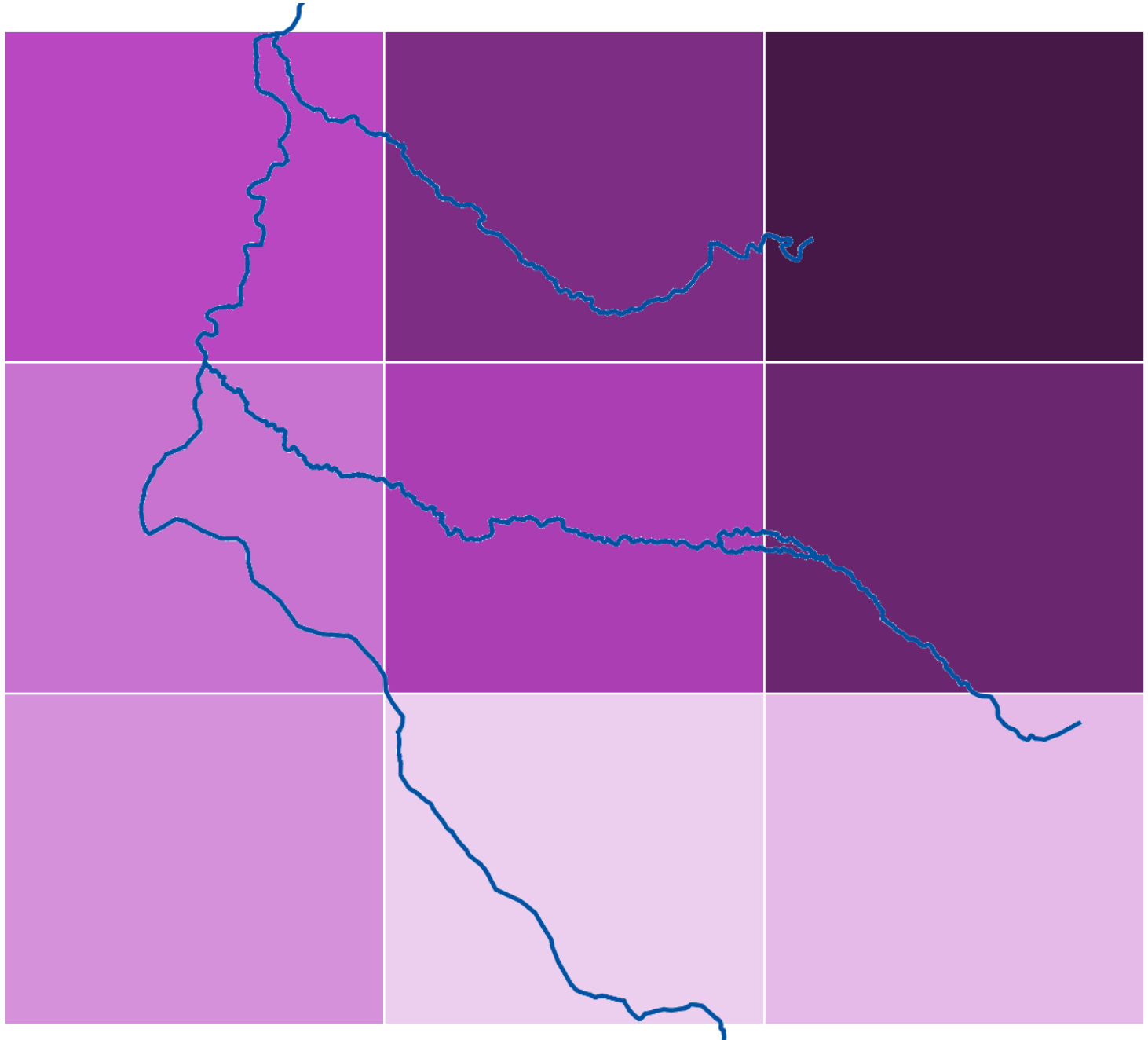
Data Resolution



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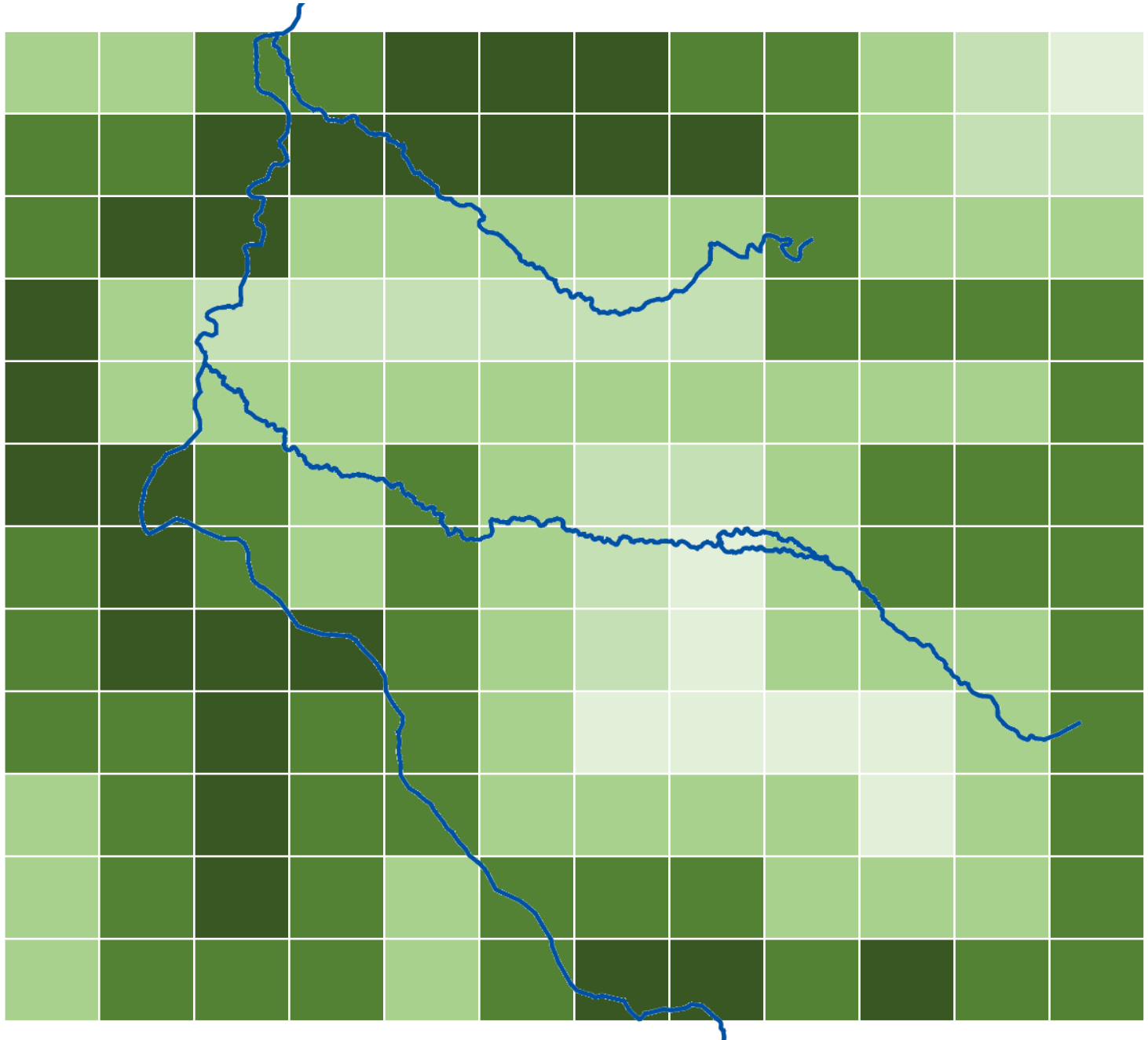
Data Resolution



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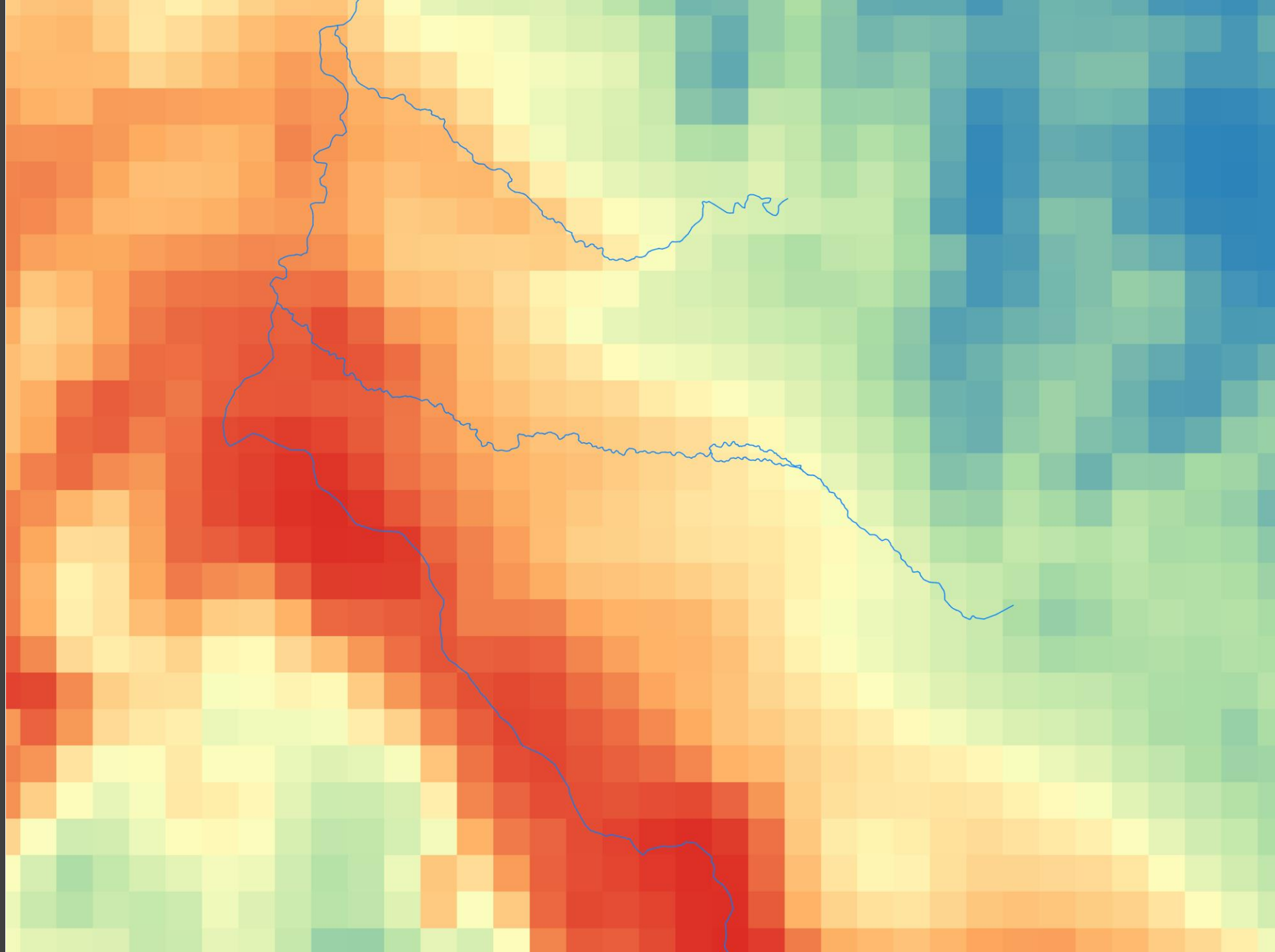
Precipitation



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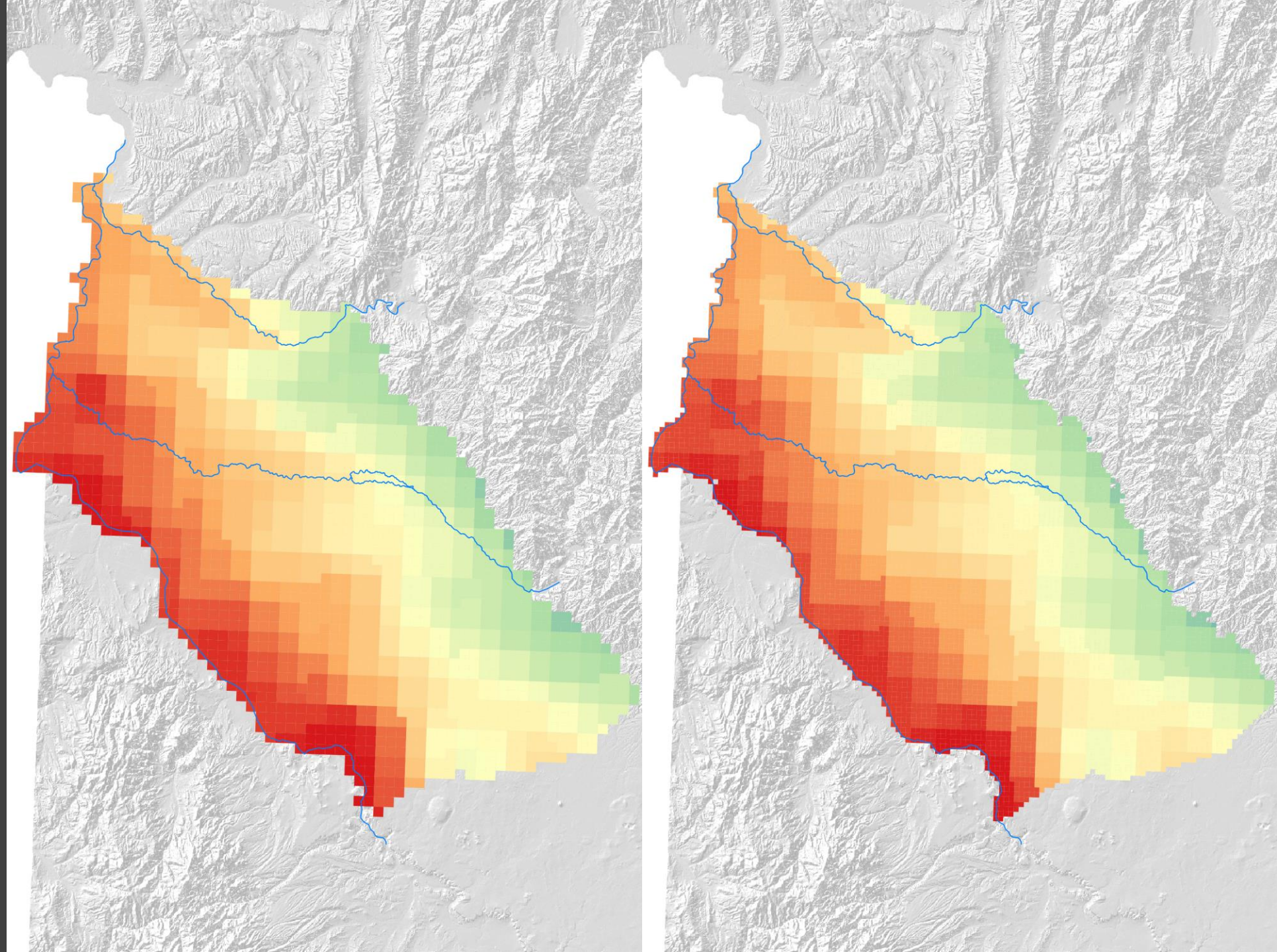
Precipitation



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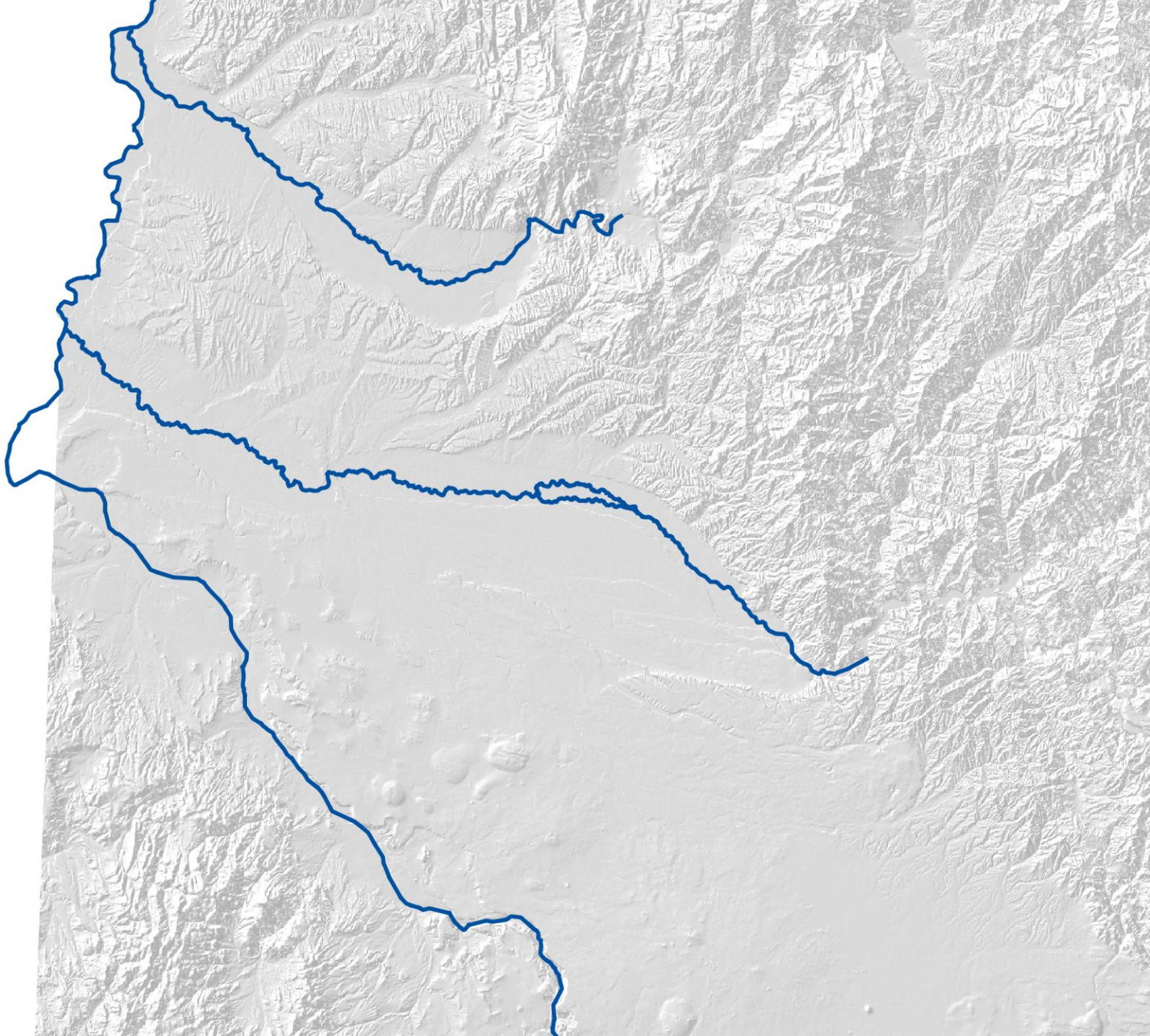
River Location



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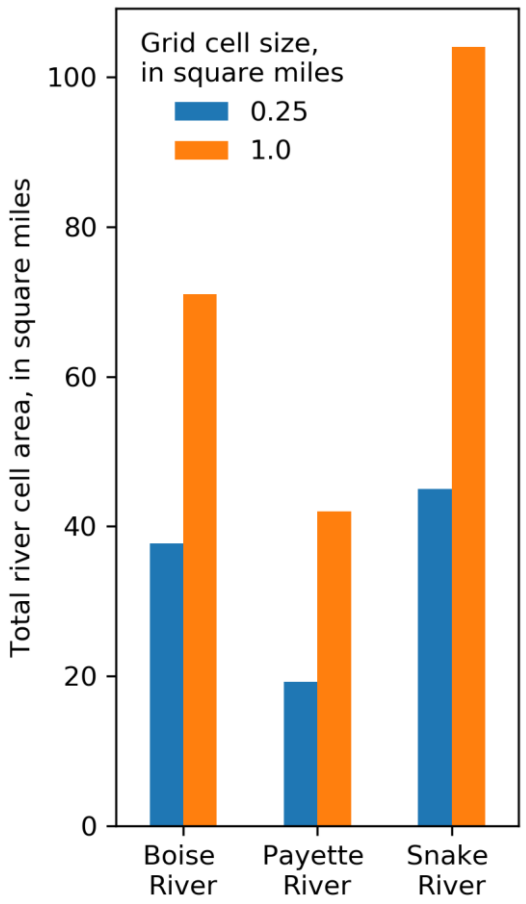
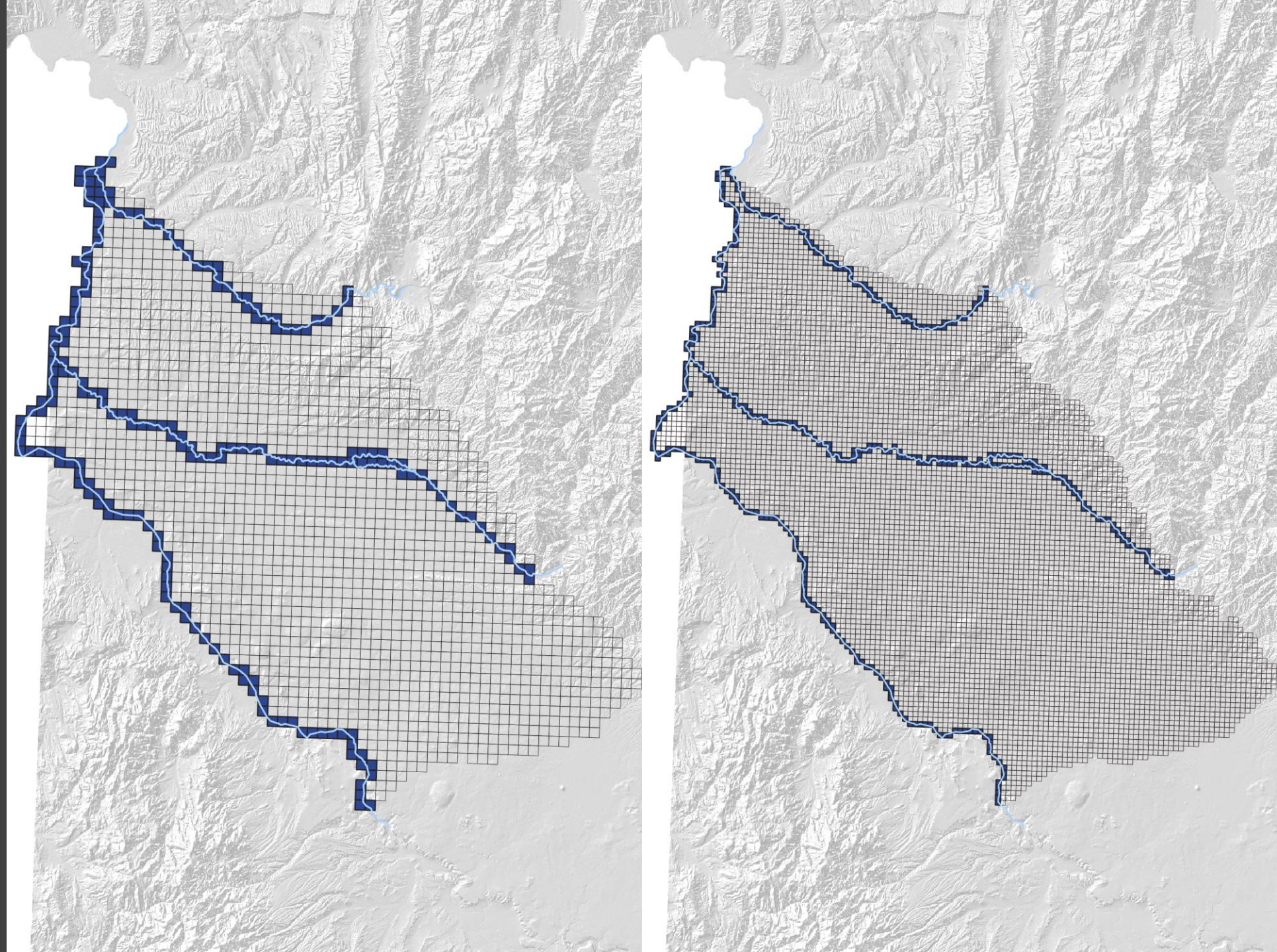
River Location





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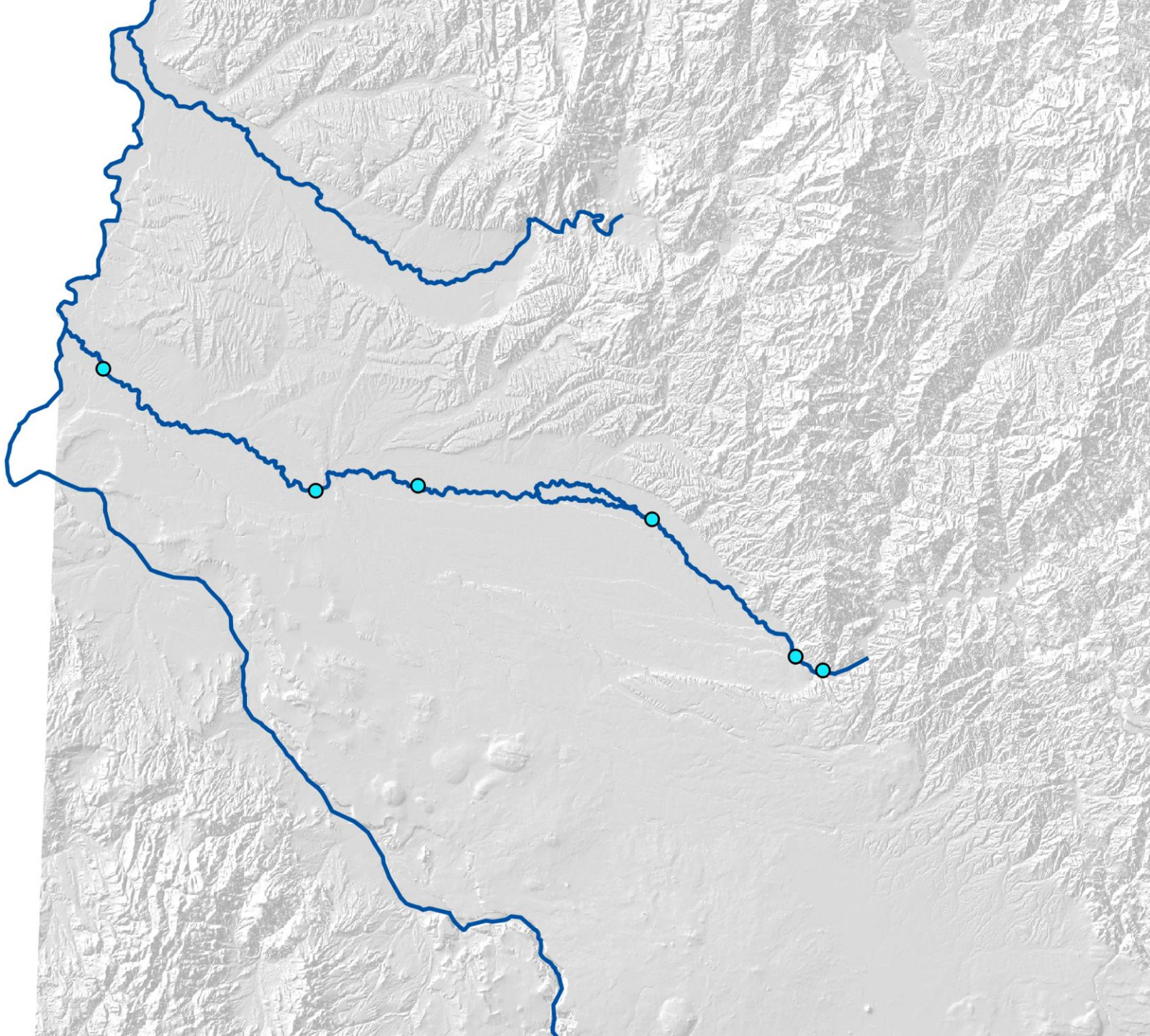
River Seepage



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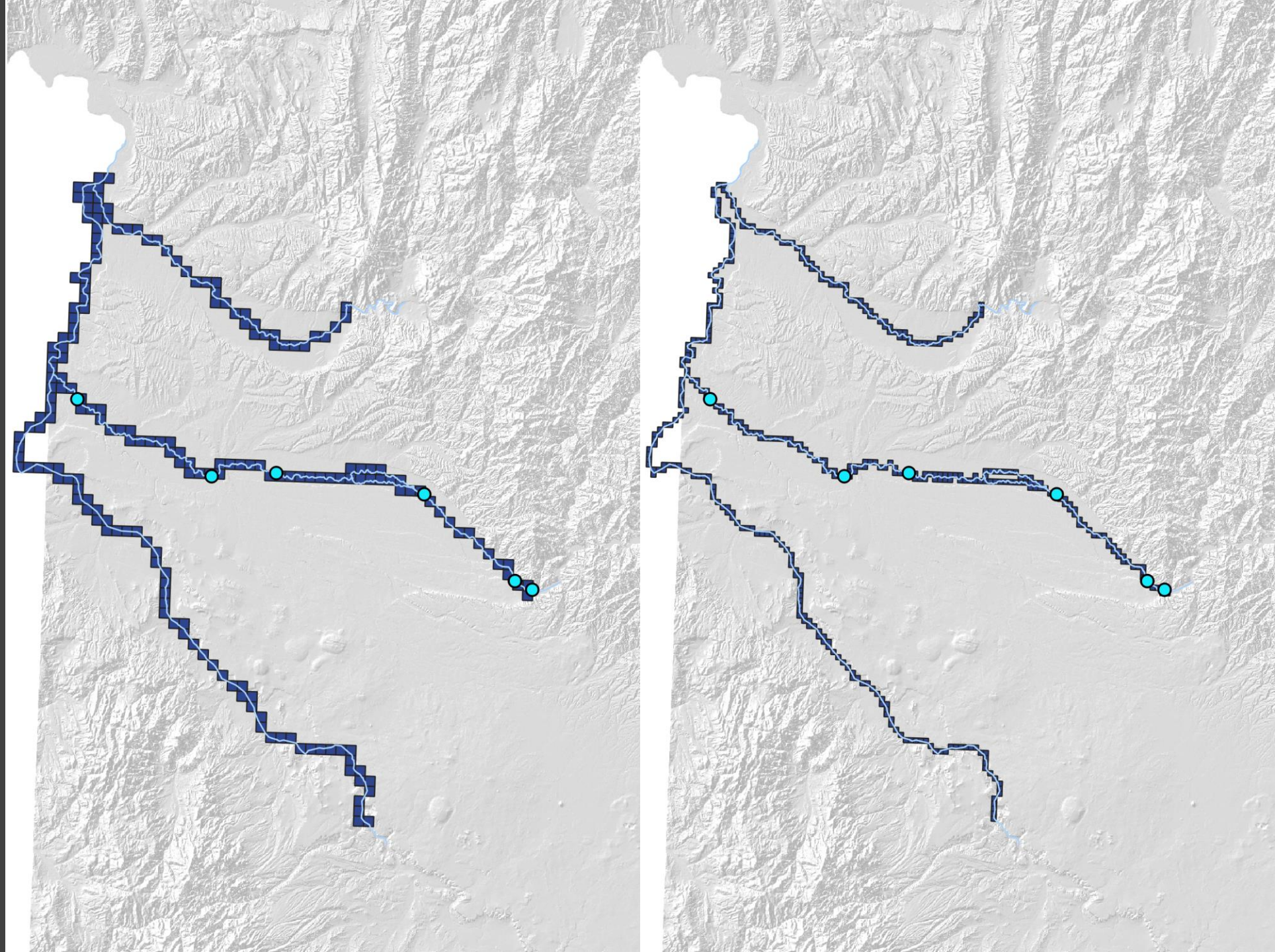
River Seepage



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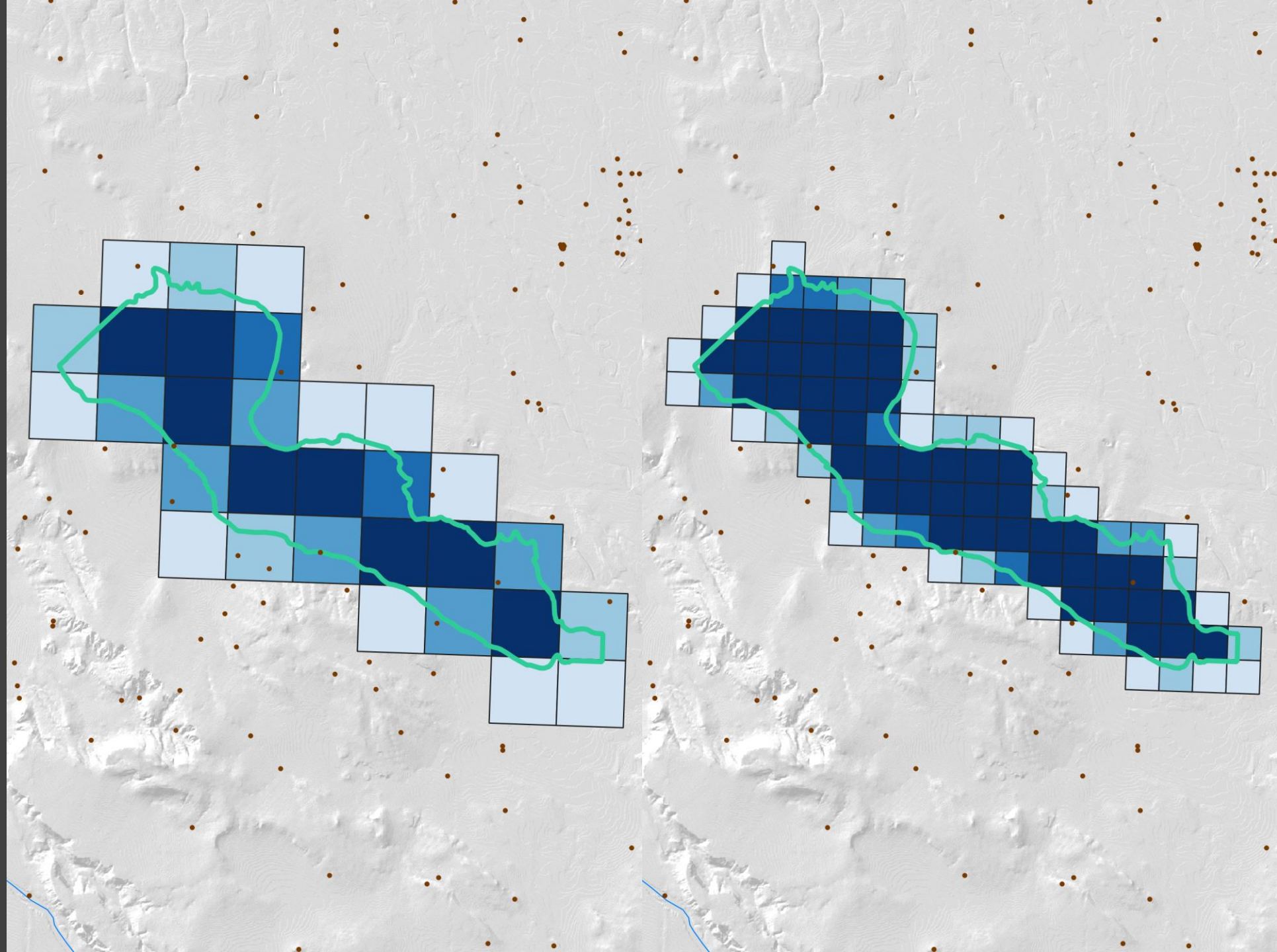
Lake Lowell



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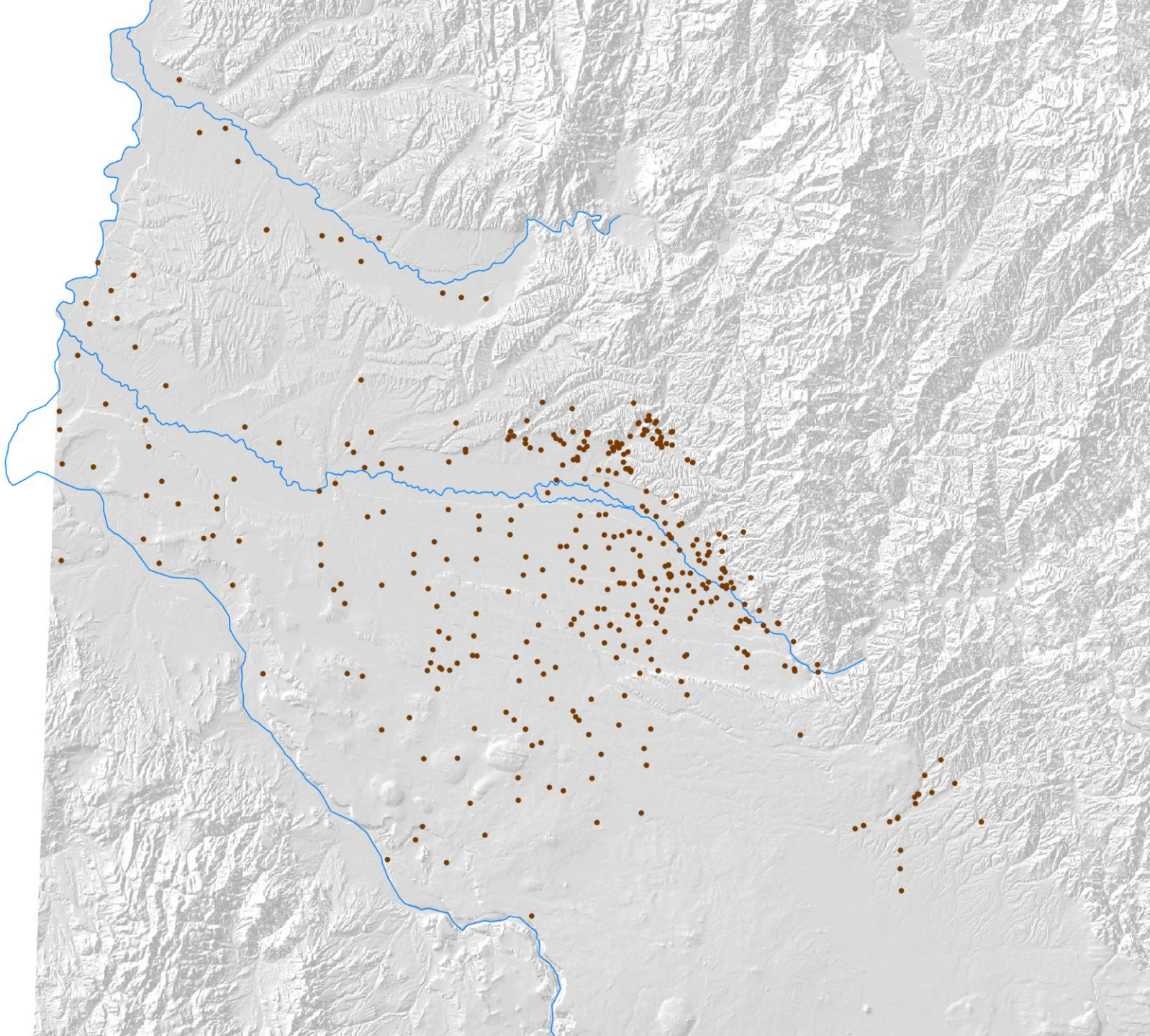
Water Levels

Observation Wells:

Layer 1



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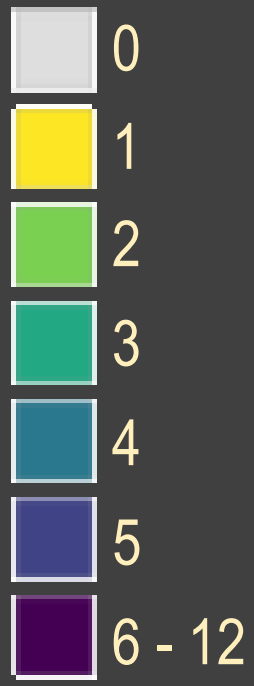
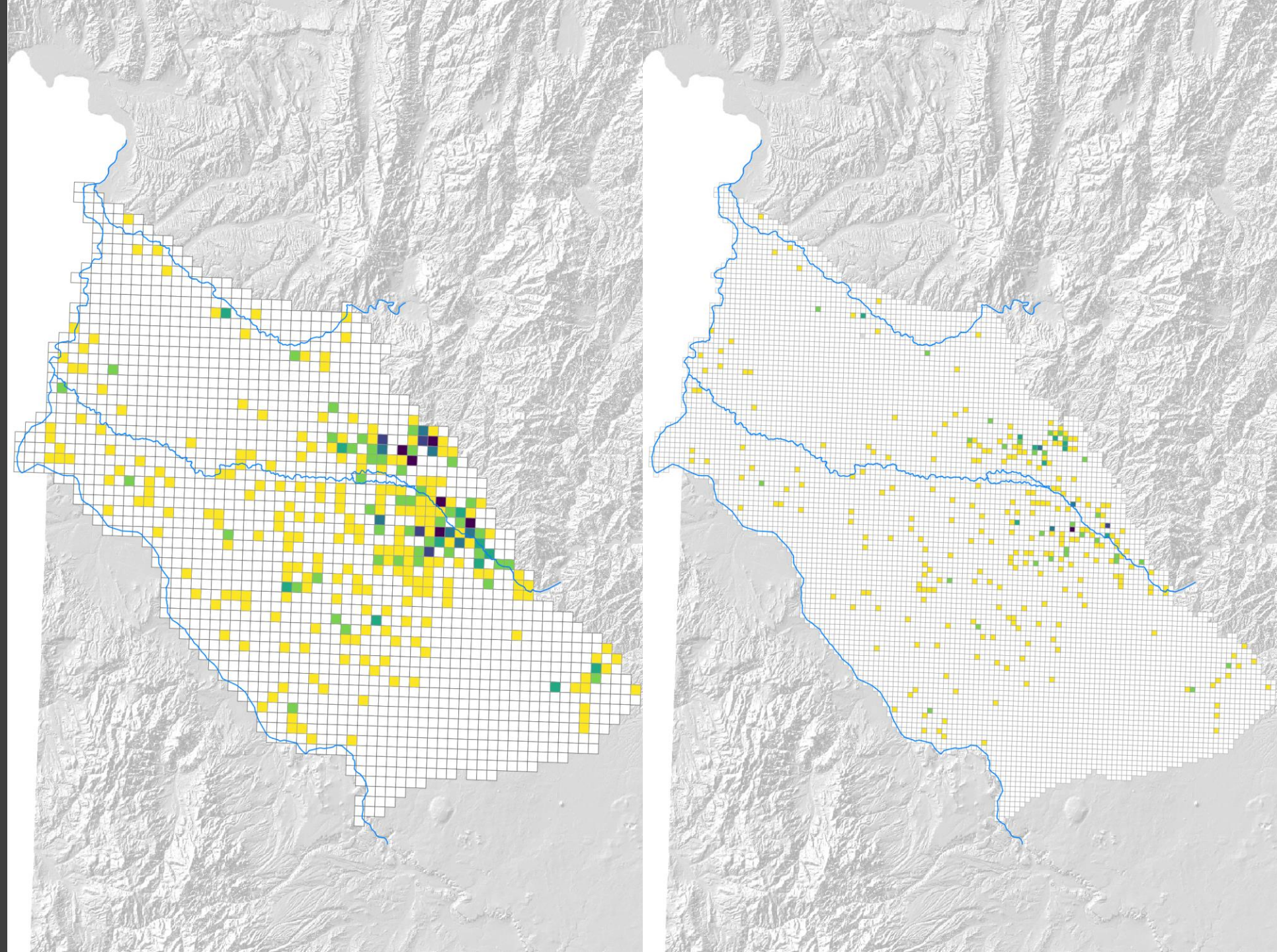
Water Levels

Observation Wells per Cell:

Layer 1





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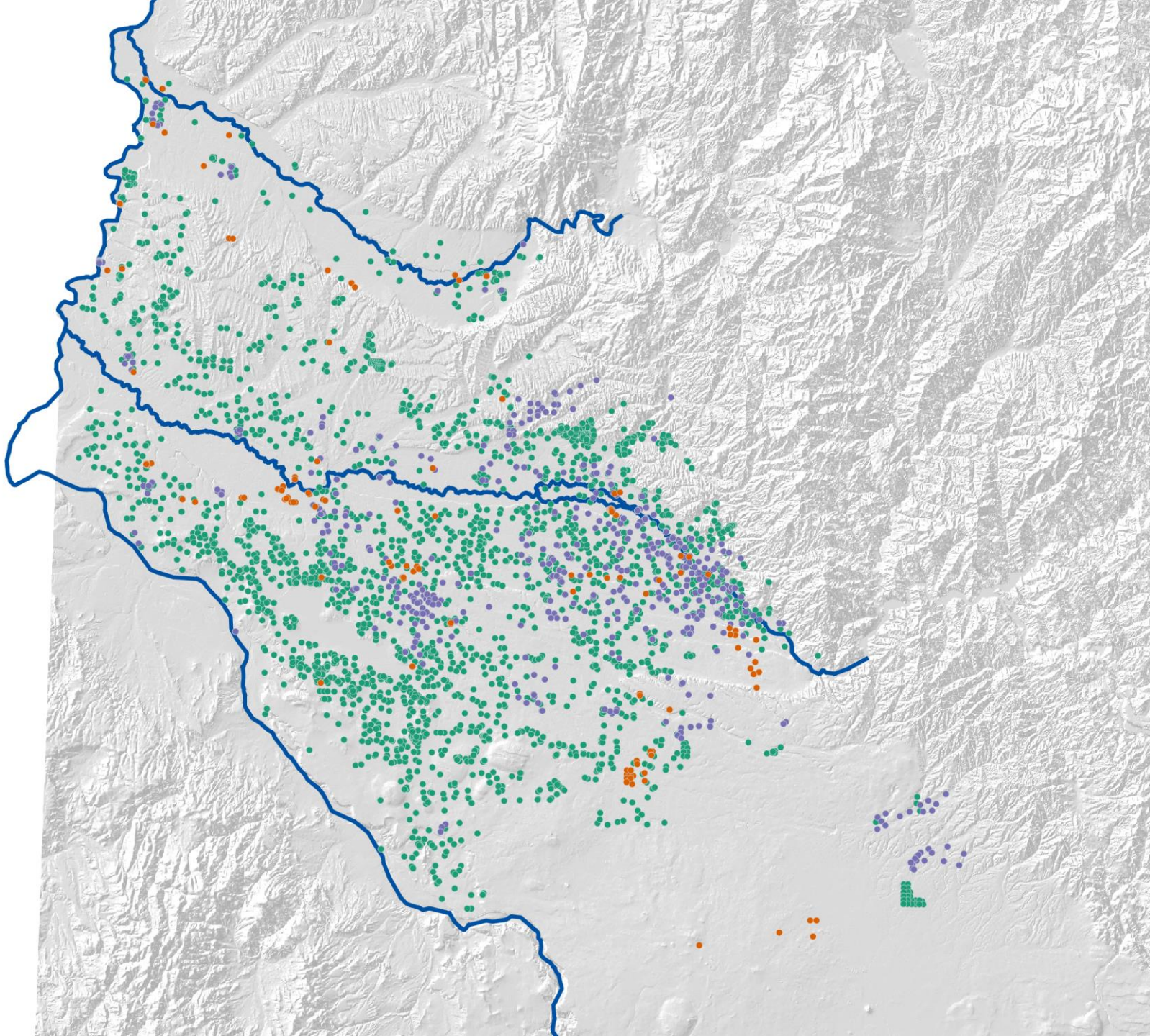
Pumping Wells



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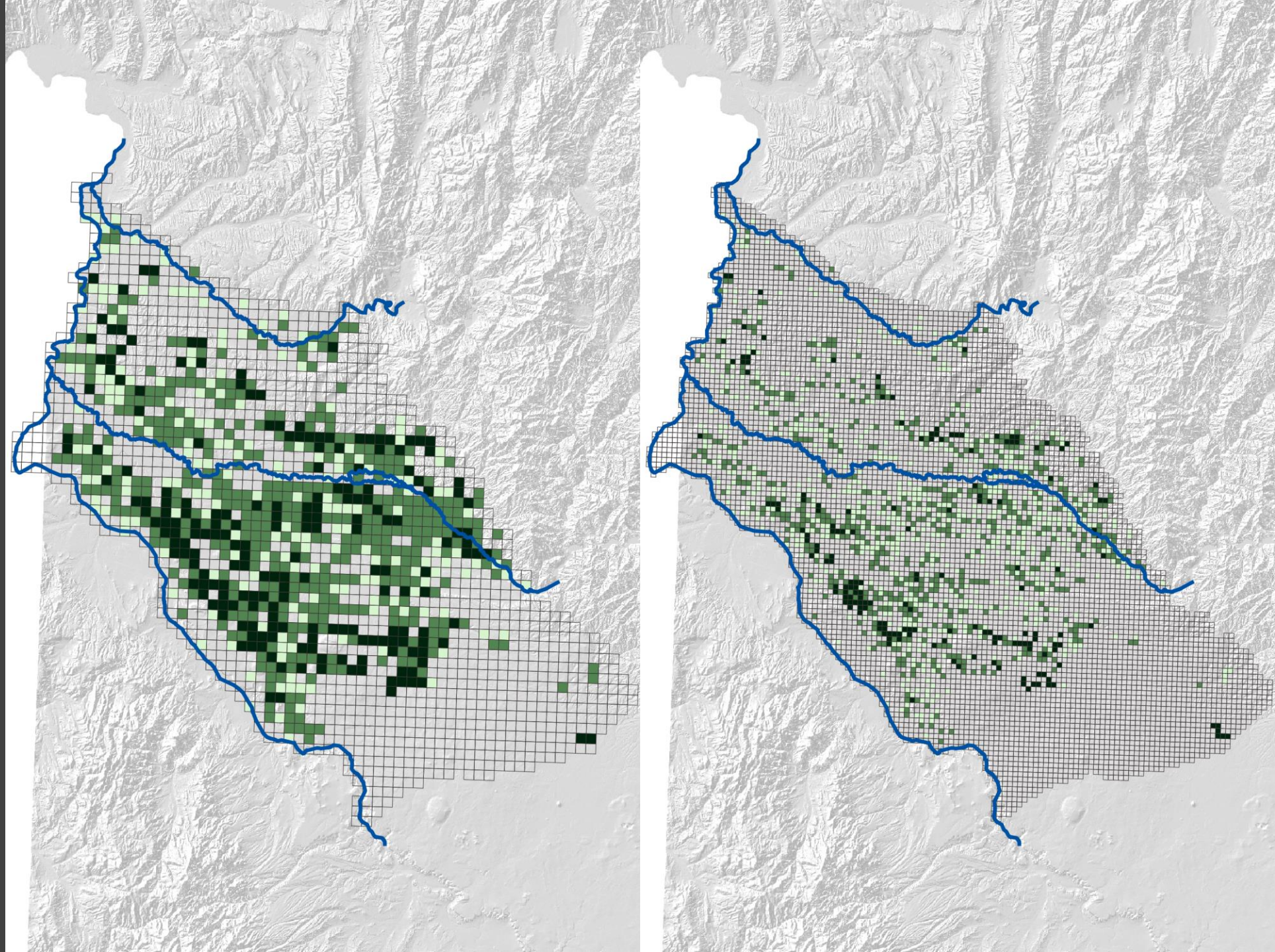
Pumping Wells

Irrigation Wells per Cell:

All Layers

- 1
- 2
- 3



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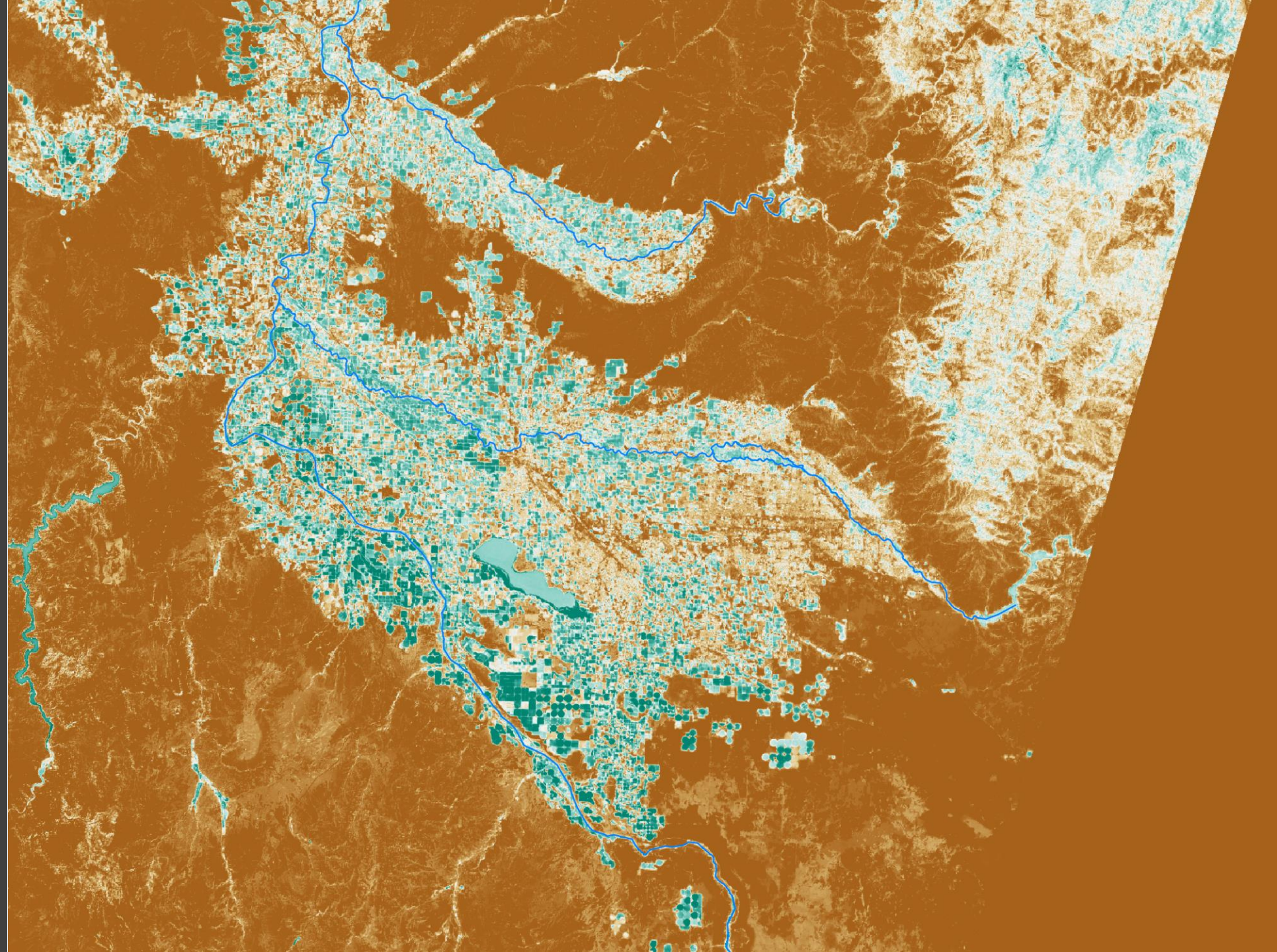
Evapo-transpiration



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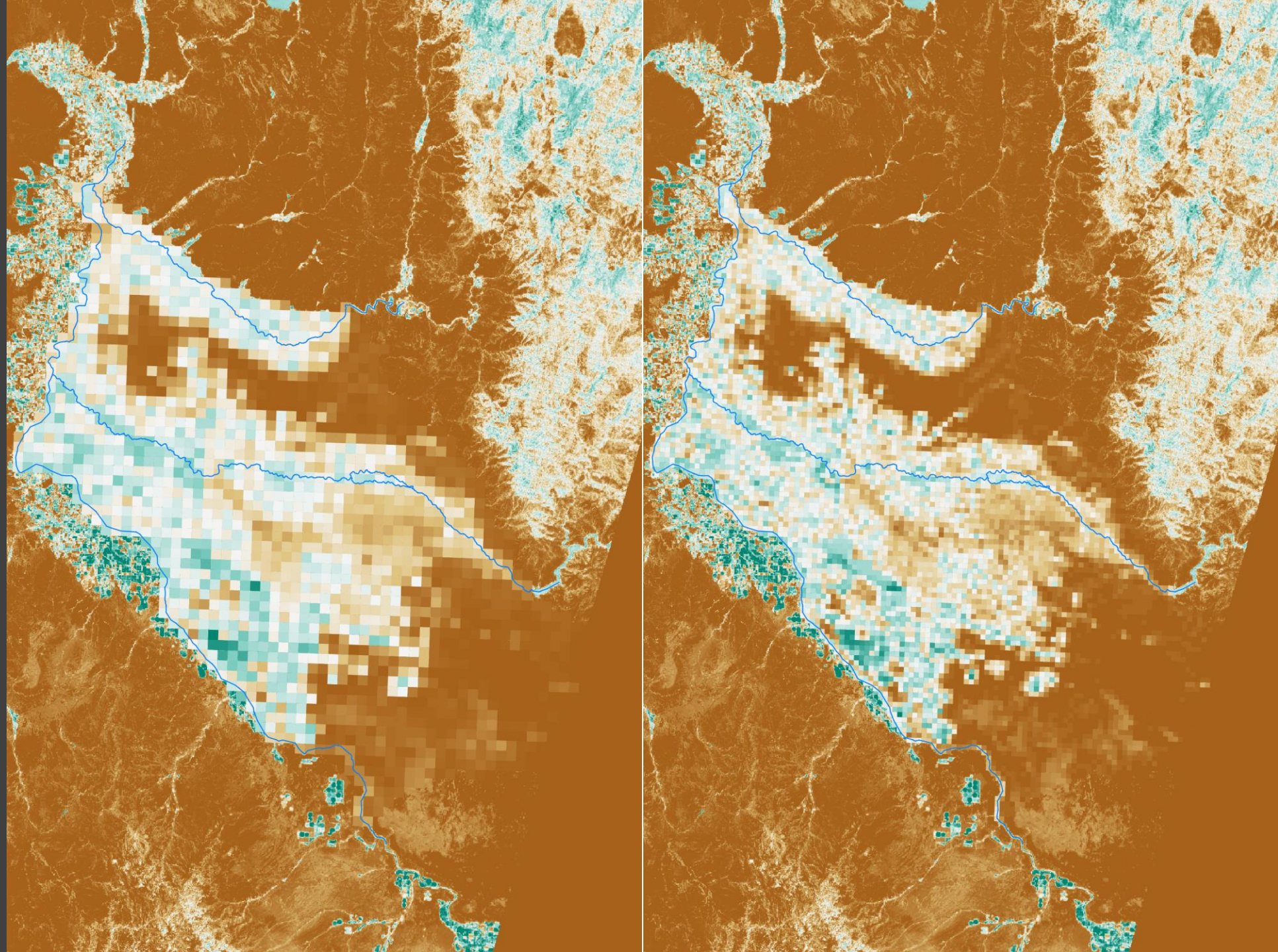
Evapo-transpiration



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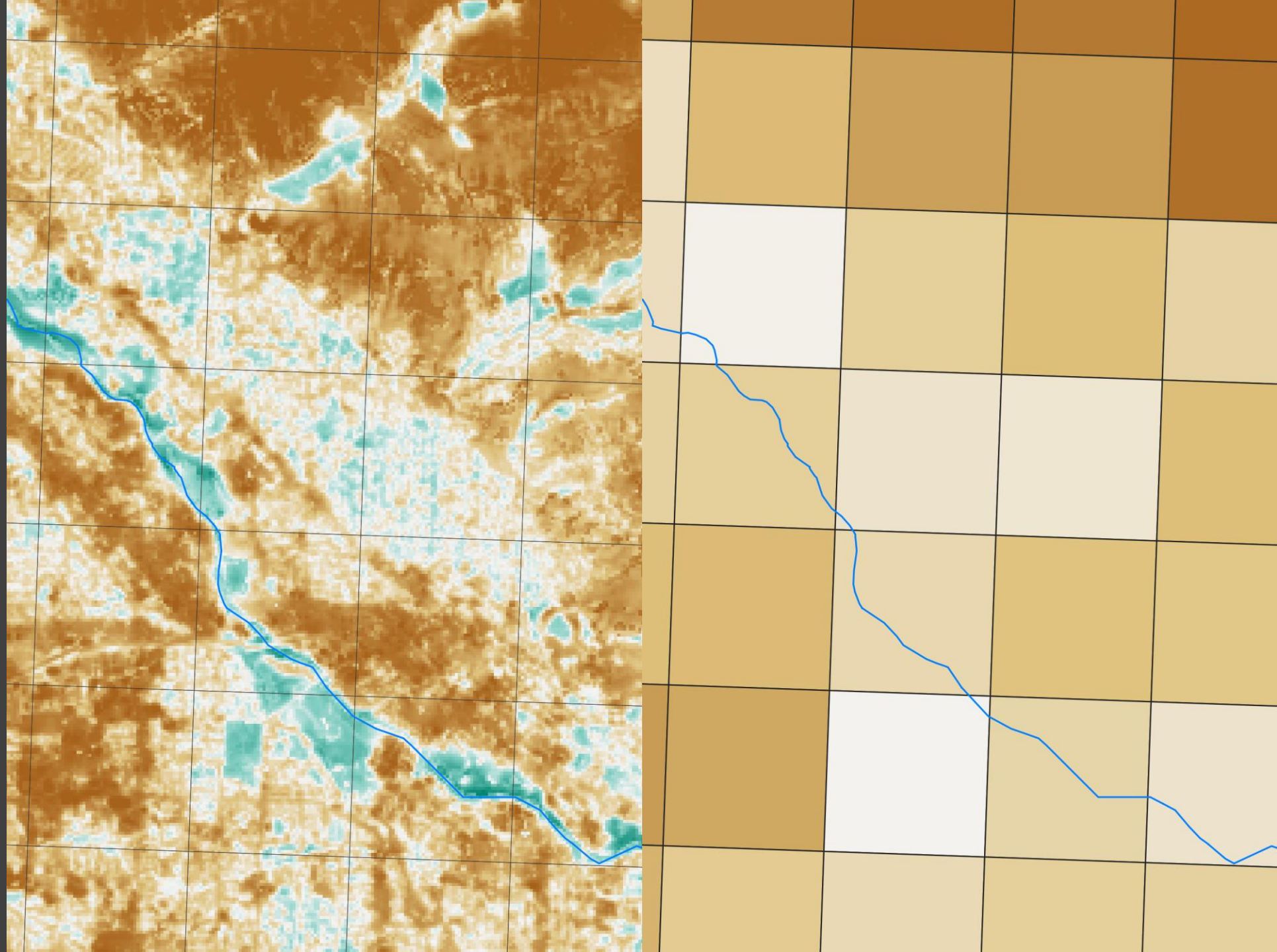
Evapo-transpiration



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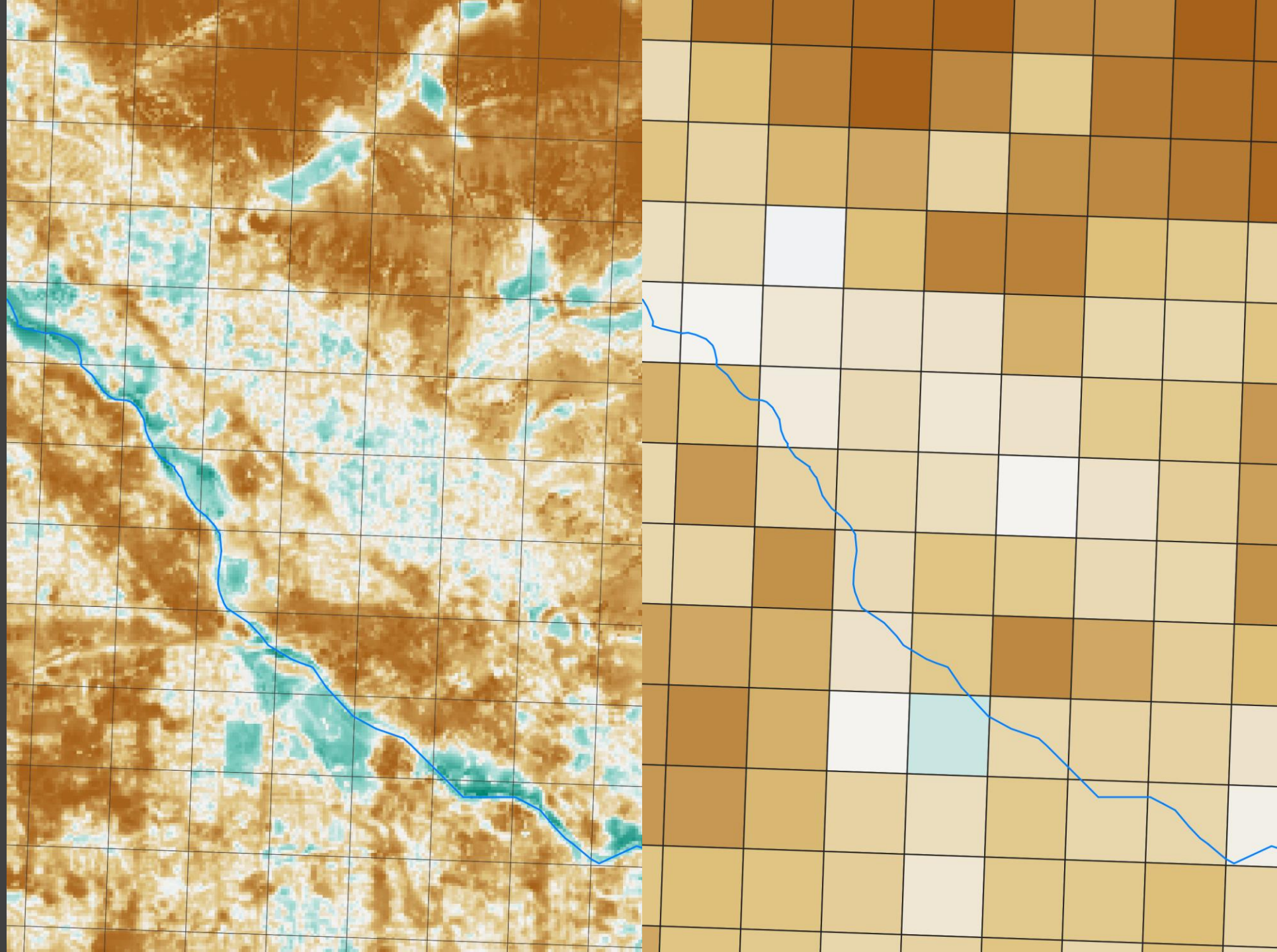
Evapo-transpiration



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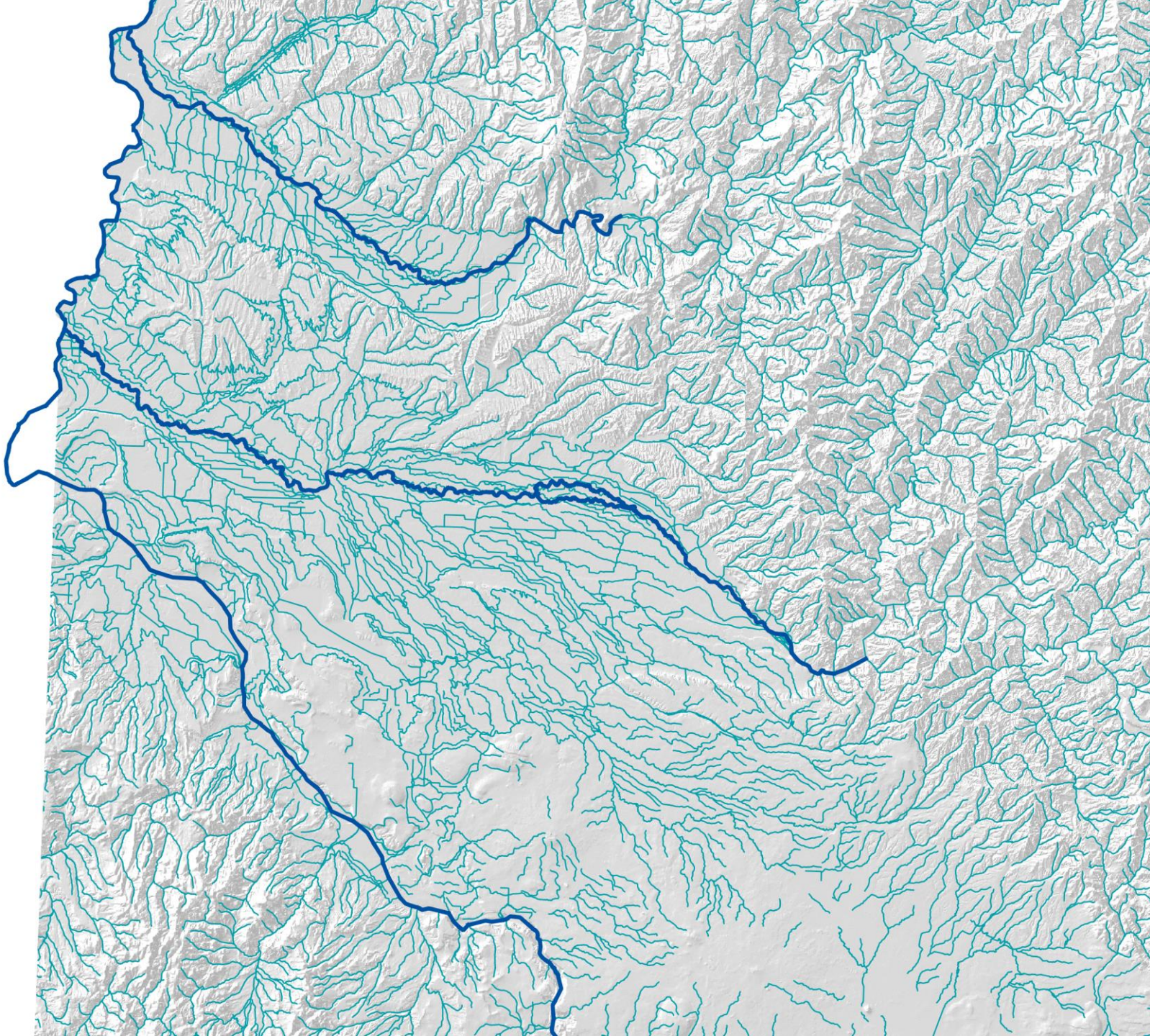
Drain Locations



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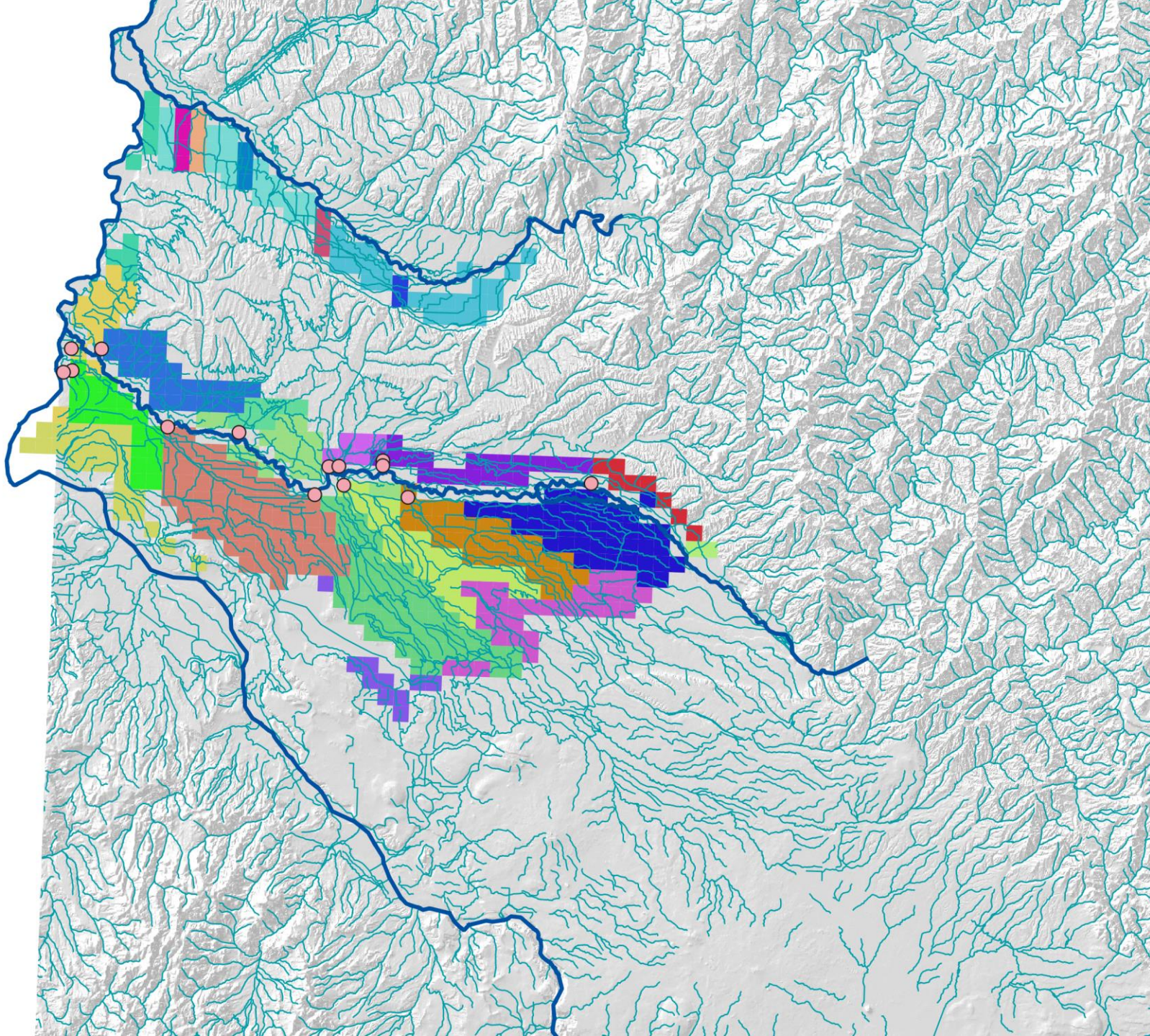
Drain Flows



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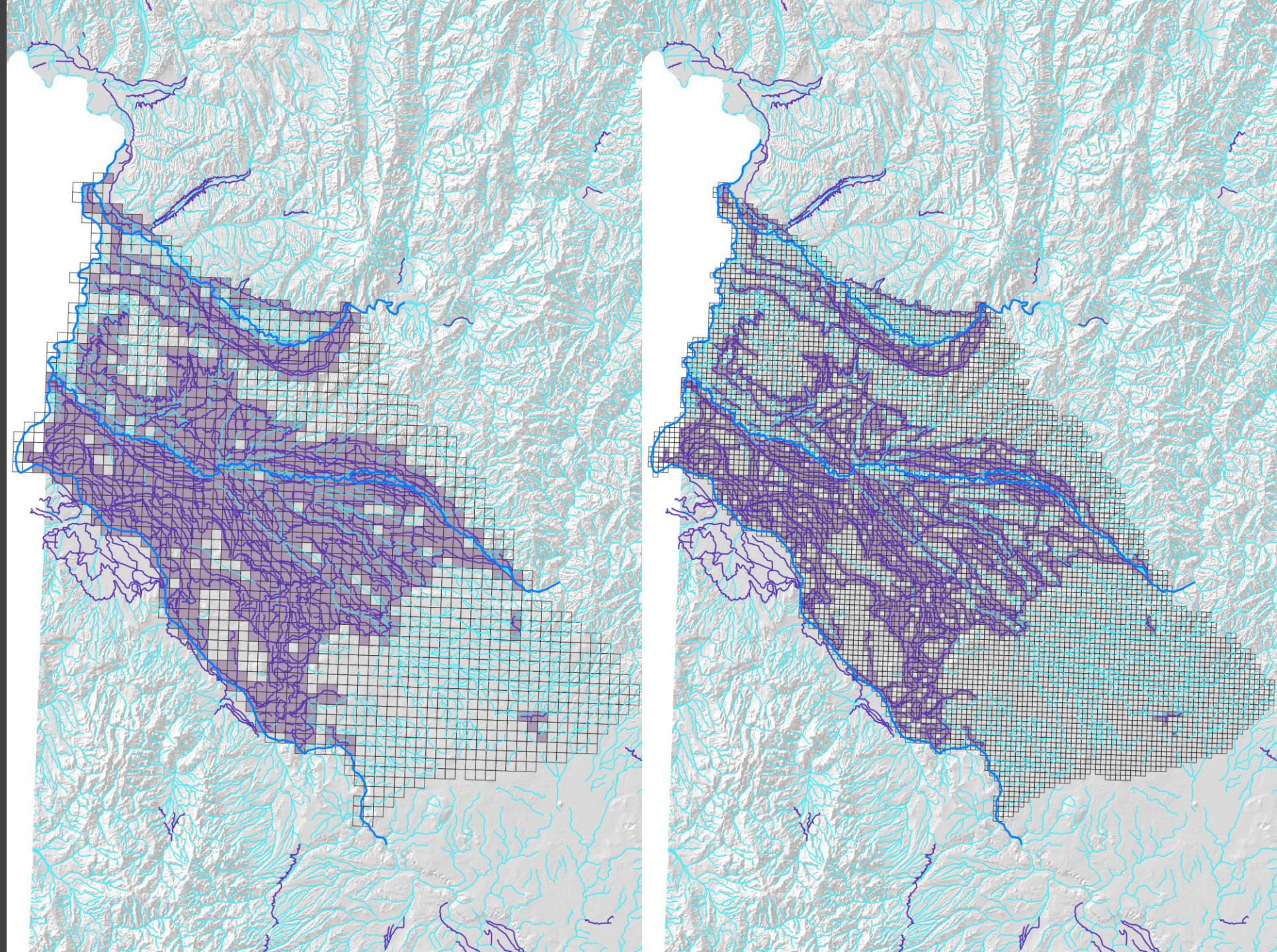
Canal Locations



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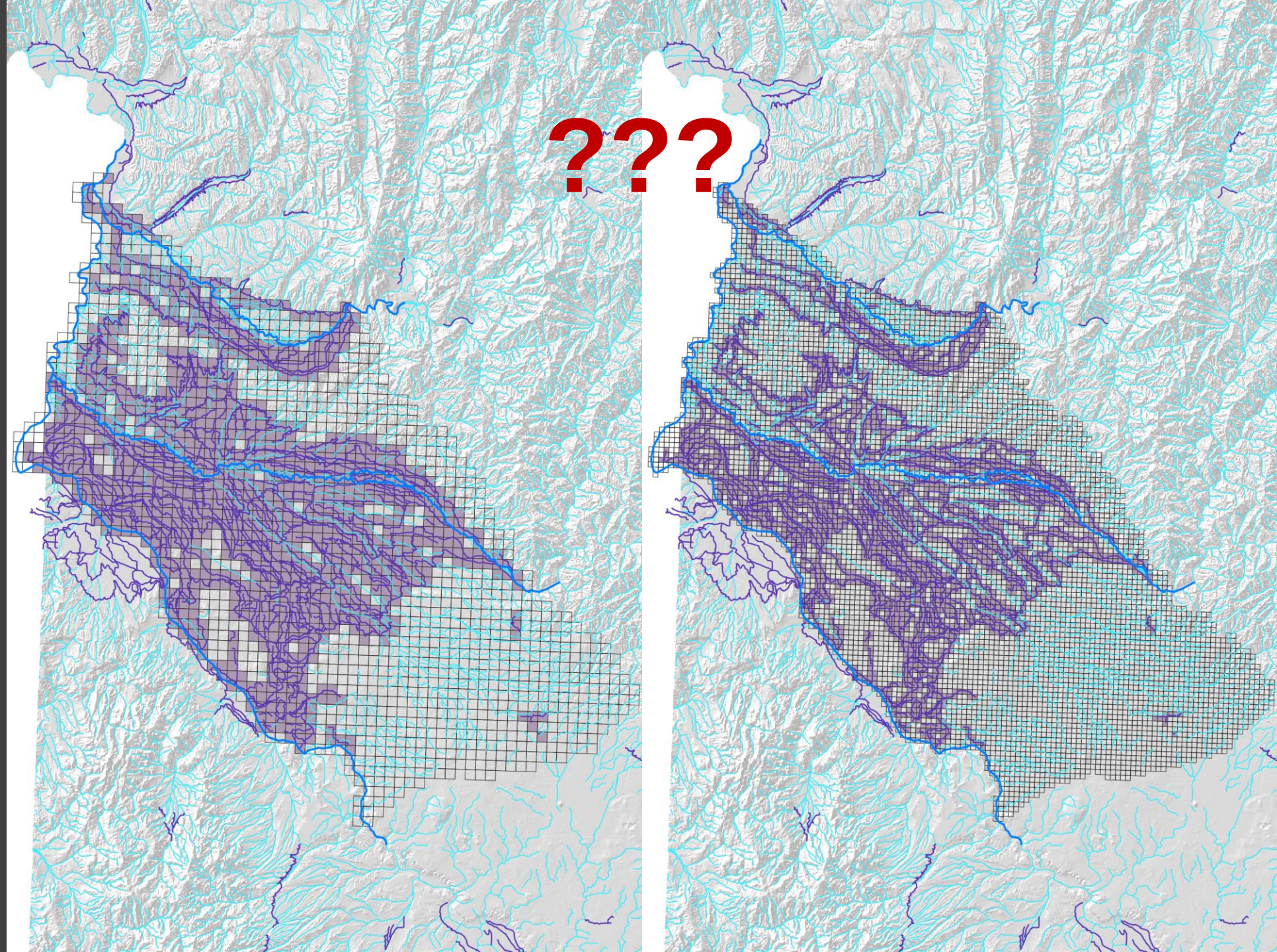
Canal Leakage

Only one seepage run exists – on NY Canal

No other direct information on leakage distribution or quantities

Irrigation entity deliveries



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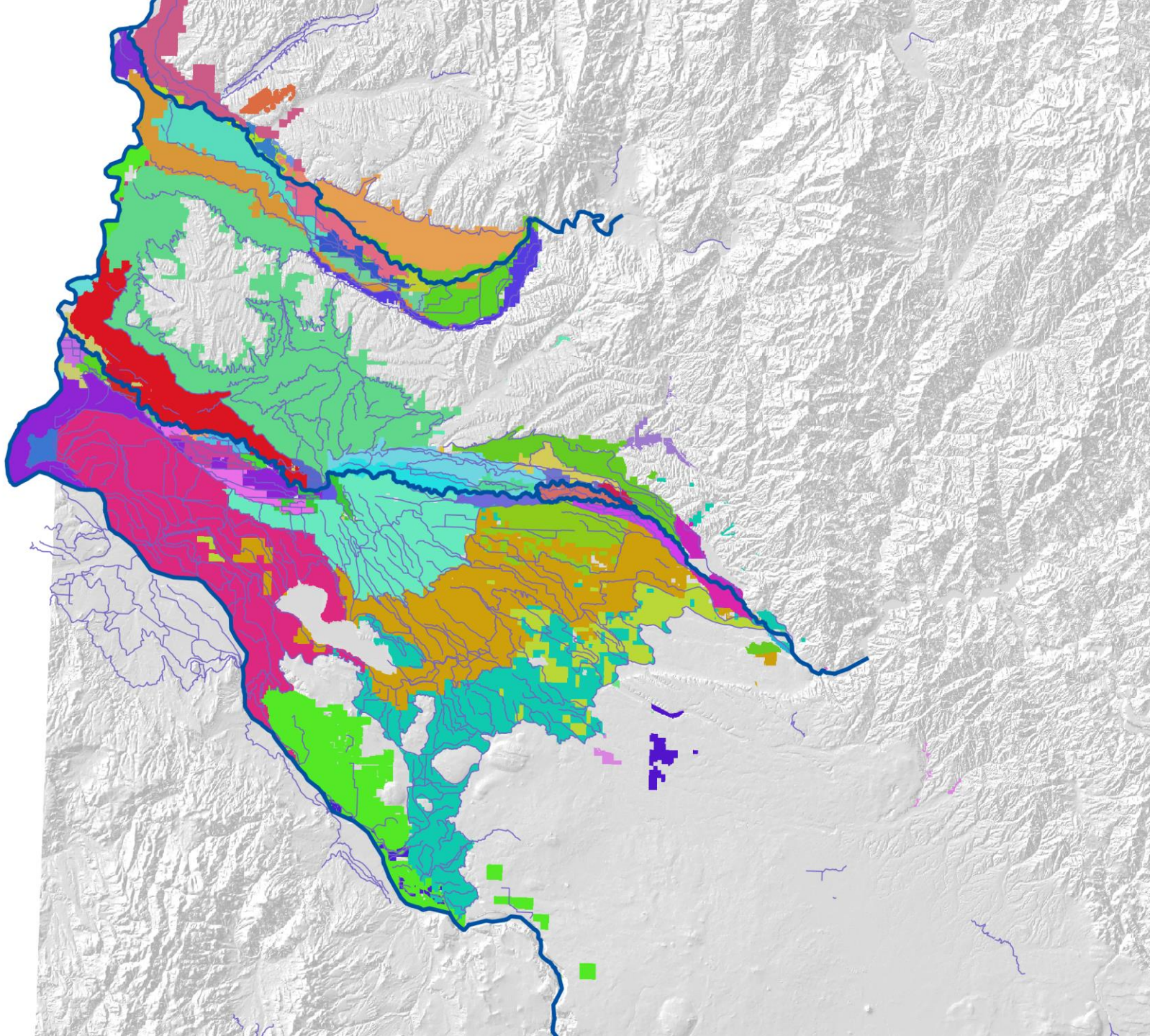
SW Irrigation Distribution



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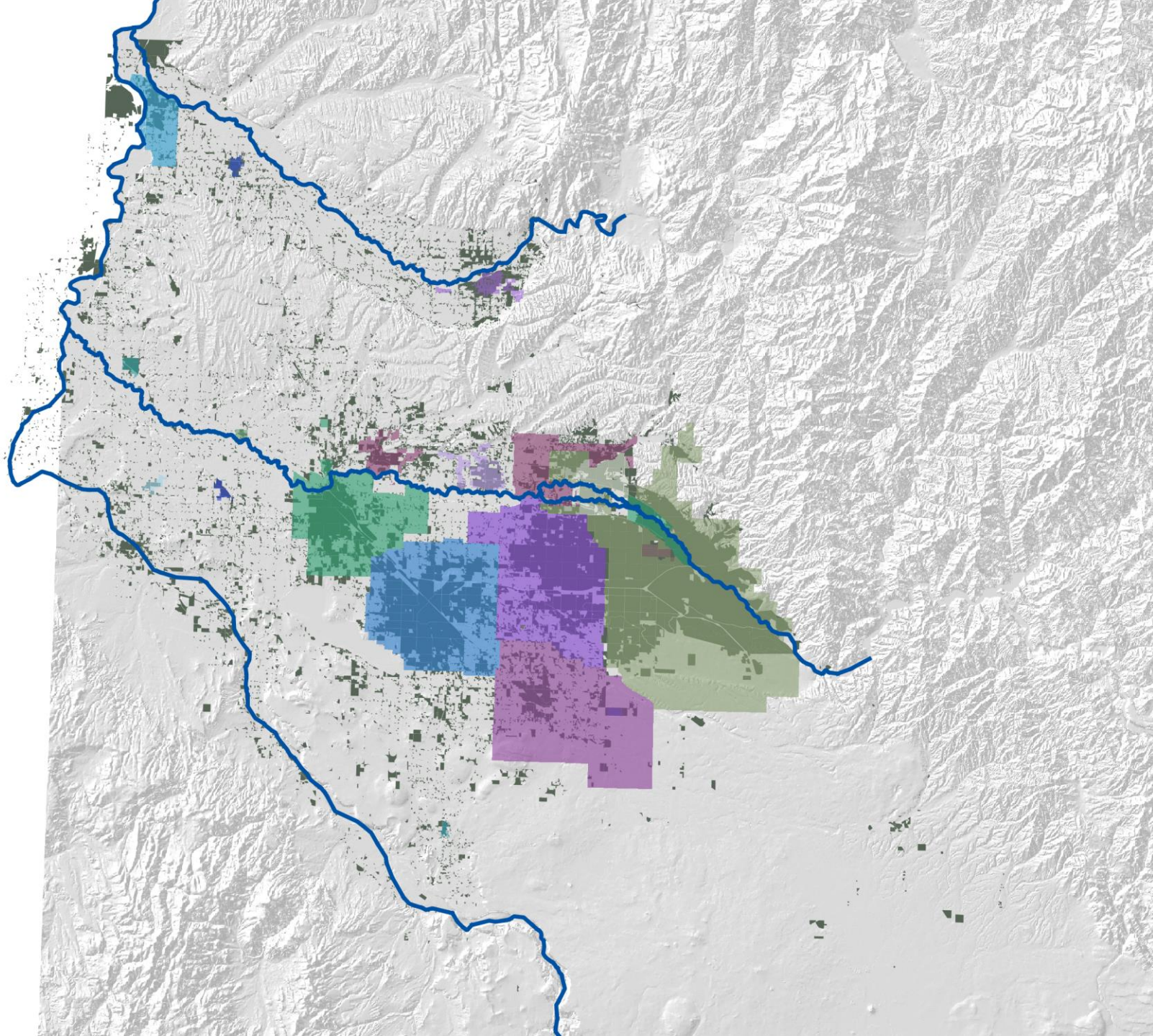
Municipal Deliveries



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Summary

Dataset	Spatial Scale
Precipitation	> 1 mile
Evapotranspiration	<< ½ mile
Well locations	<< ½ mile
Well pumping distribution	???
Irrigation district boundaries	<< ½ mile
SW irrigation distribution	>> 1 mile
Incidental recharge	???
Canal locations	<< ½ mile
Canal seepage distribution	>> 1 mile
Drain locations	<< ½ mile
Drain seepage distribution	>> 1 mile
River locations	<< ½ mile
River seepage distribution	> 1 mile
Lowell boundary	<< ½ mile
Lowell seepage distribution	>> 1 mile
Underflow distribution	>> 1 mile

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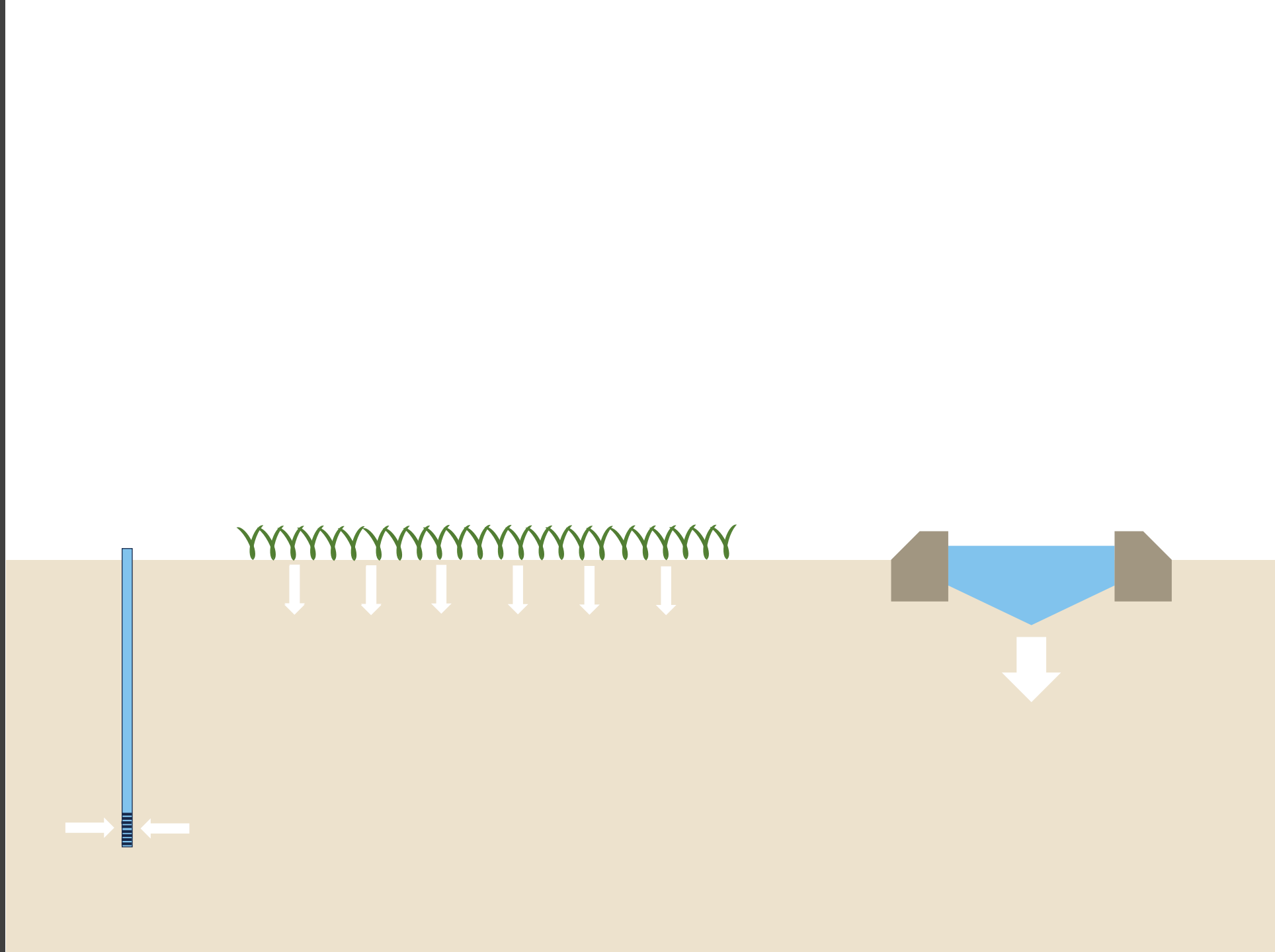
Canal Leakage, Incidental Recharge, & Pumping



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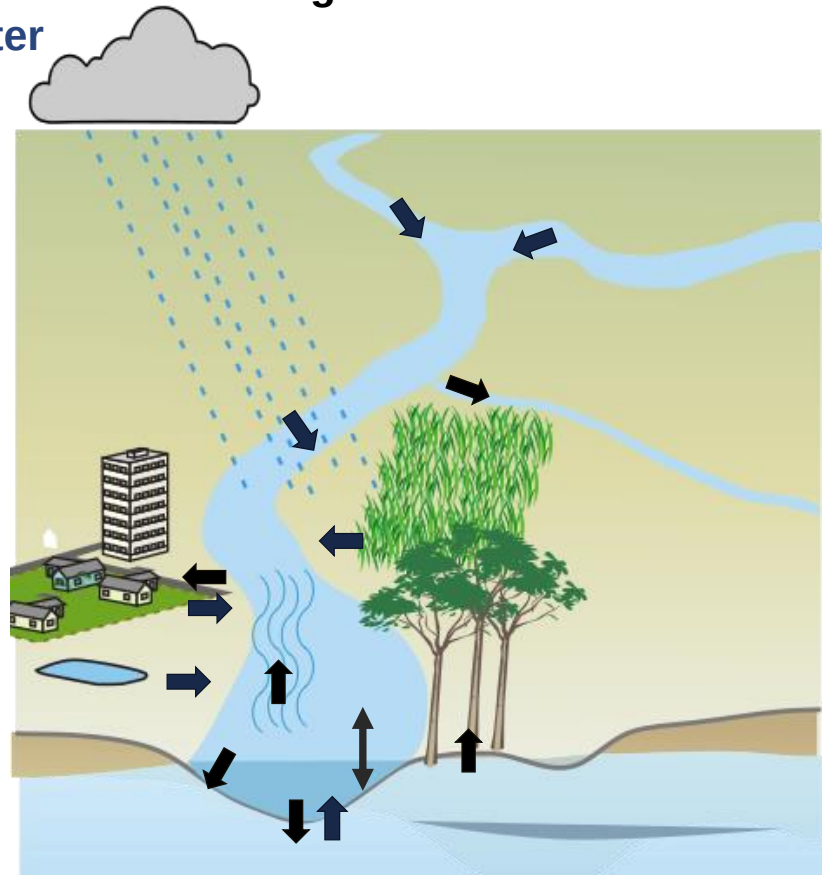
In – Out = ±ΔStorage

upstream inflow
tributary inflow
runoff
treated wastewater
precipitation
gain from groundwater

downstream outflow
diversions (ag, urban)
transpiration from riparian vegetation
evaporation
loss to groundwater

Δ instream volume (negligible)



(modified from Faunt, 2009)

(Rivers &) Canals

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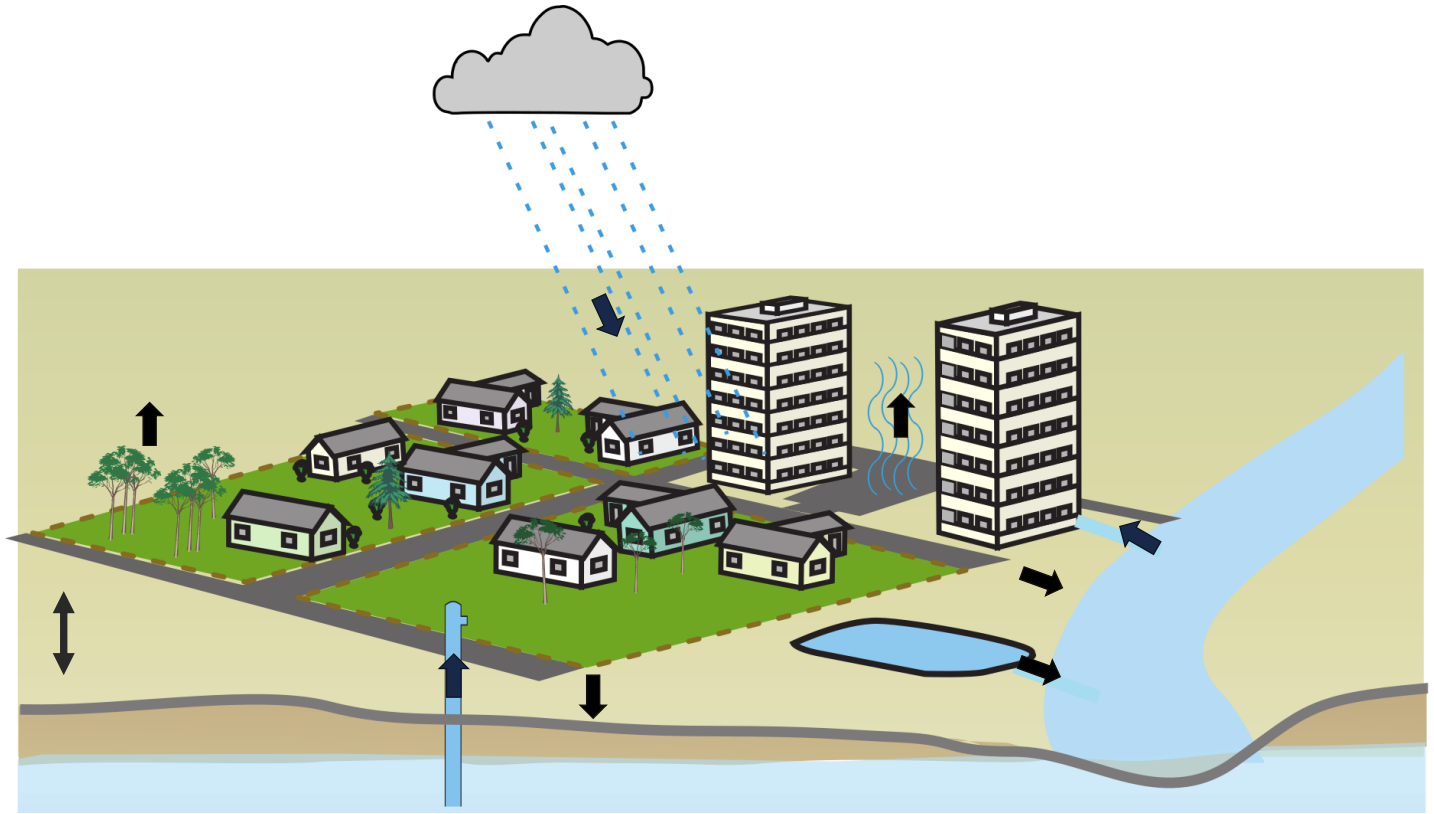
In – Out = ±ΔStorage

surface water supplies
precipitation
groundwater supplies

treated wastewater
evaporation
transpiration
runoff
deep percolation to groundwater

Δ soil moisture



(modified from Faunt, 2009)

(sub)Urban

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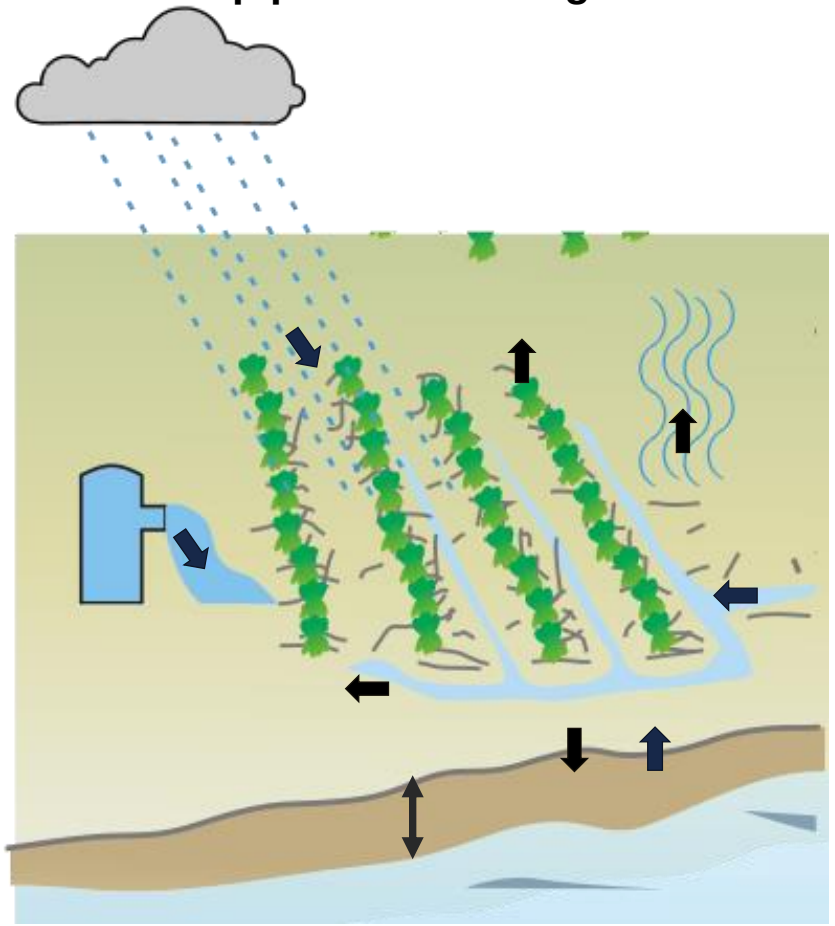
In – Out = ±ΔStorage

precipitation
surface water deliveries
groundwater deliveries
groundwater uptake

evaporation (irrigation and bare soil)
transpiration
runoff
deep percolation to groundwater

Δ soil moisture



Agricultural Soil

(modified from Faunt, 2009)

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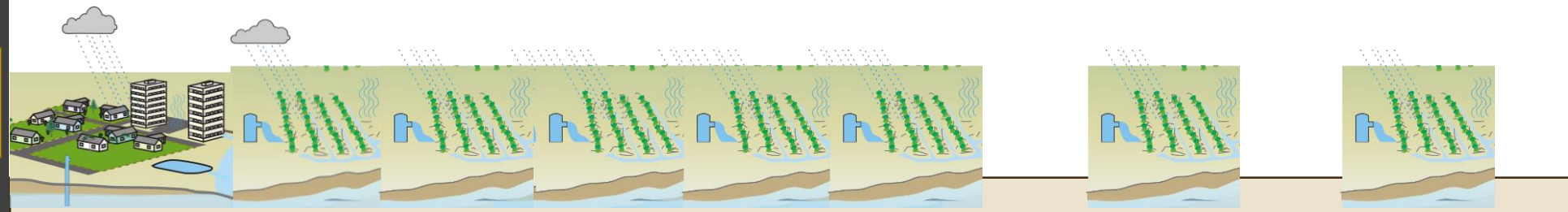
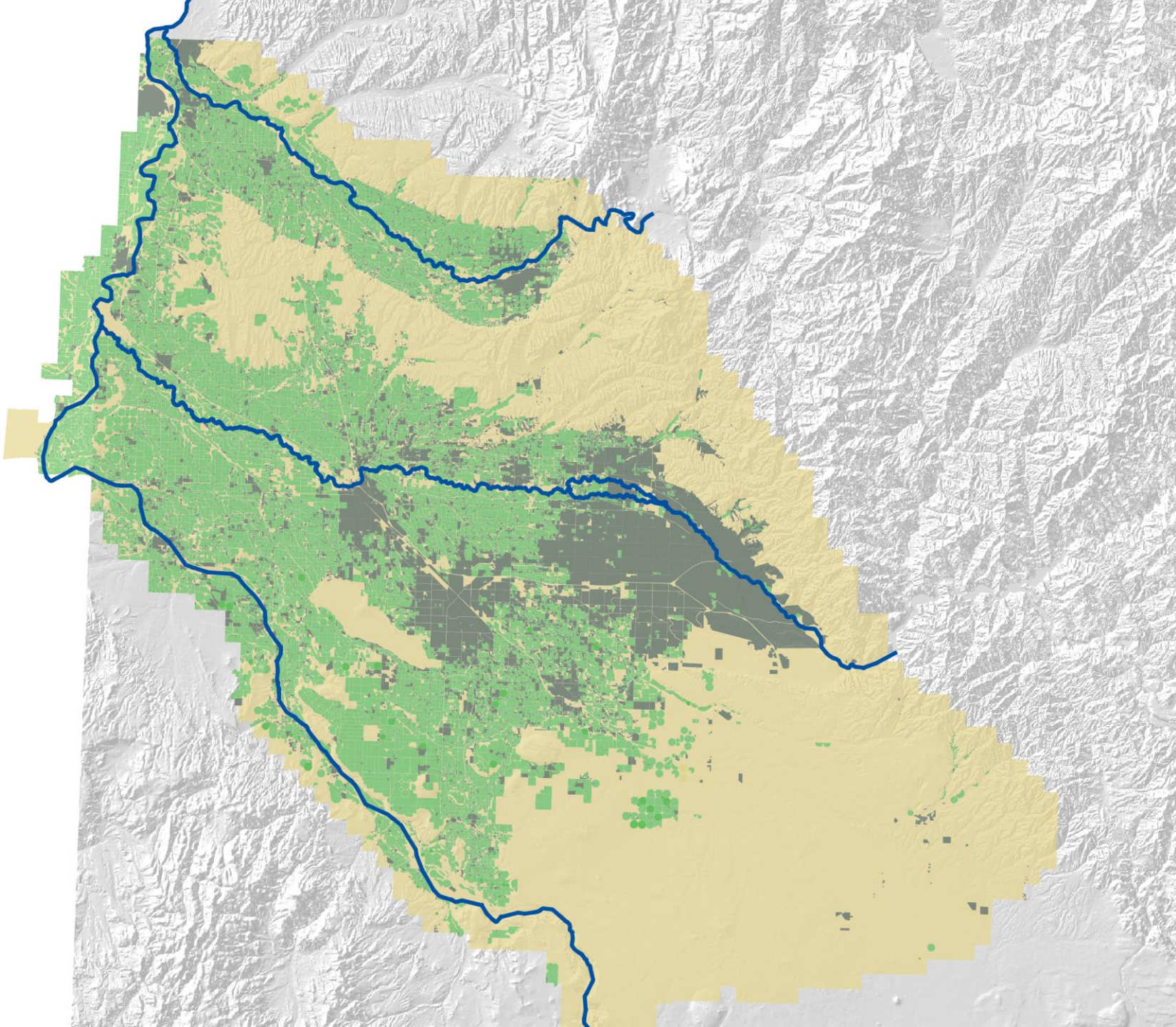
Canal Leakage, Incidental Recharge, & Pumping



Irrigated Areas



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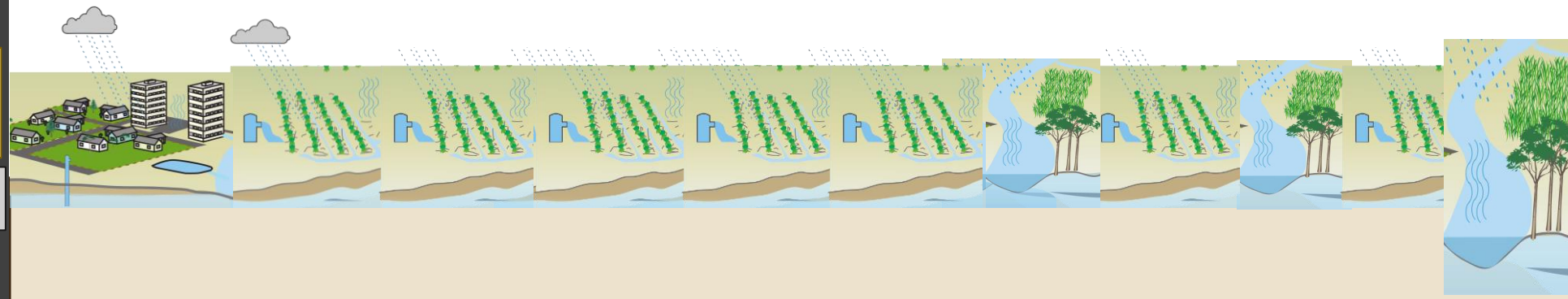
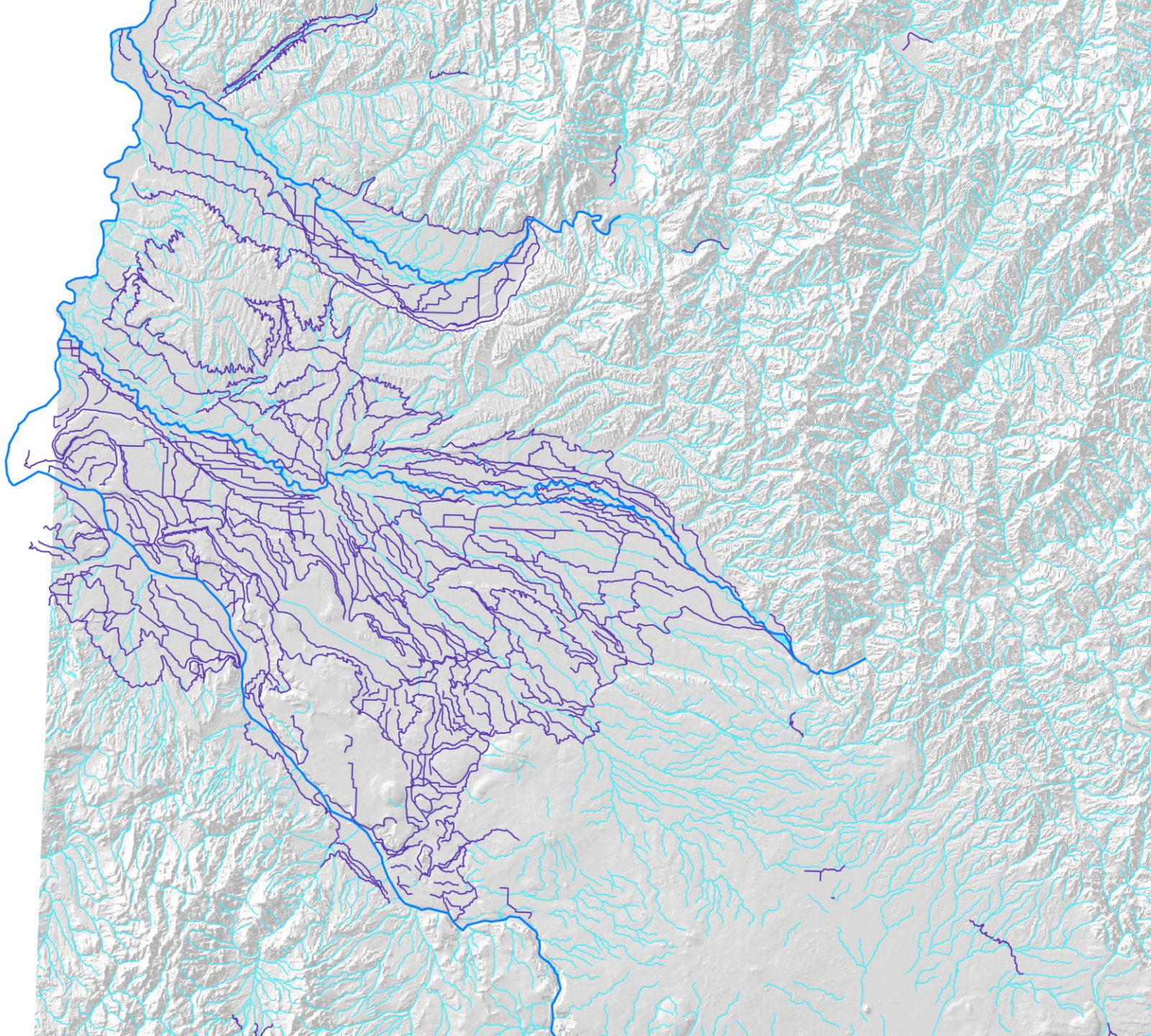
Canal Leakage, Incidental Recharge, & Pumping

irrig status

canals



Canal Locations



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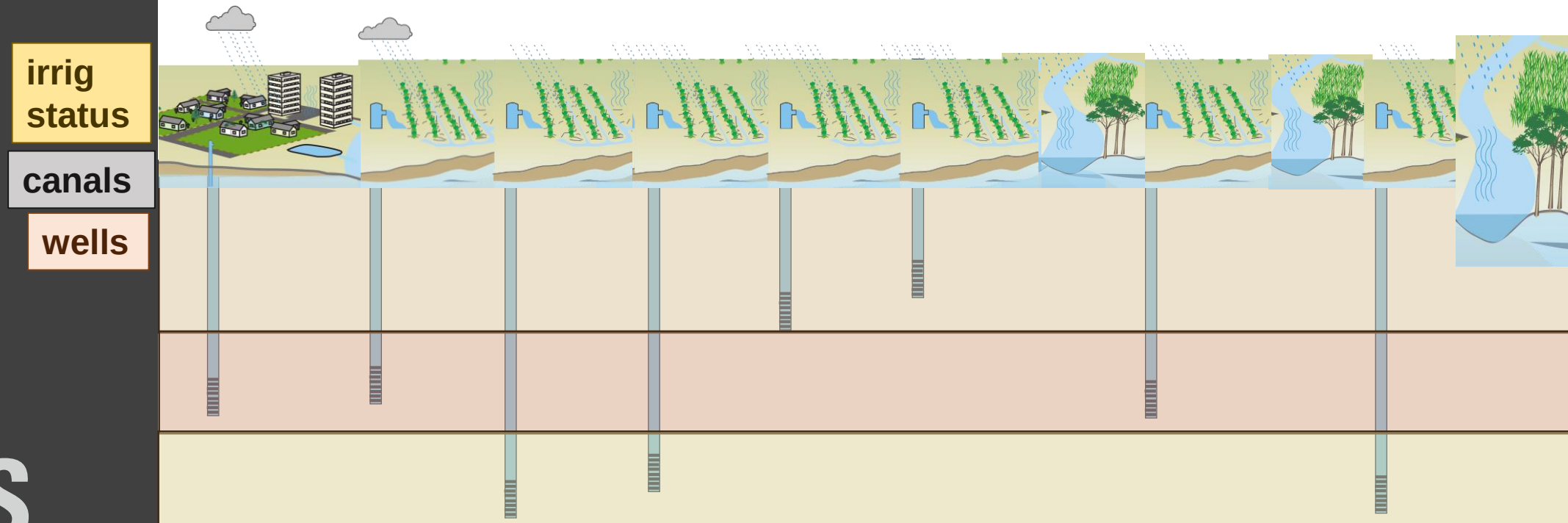
Canal Leakage, Incidental Recharge, & Pumping



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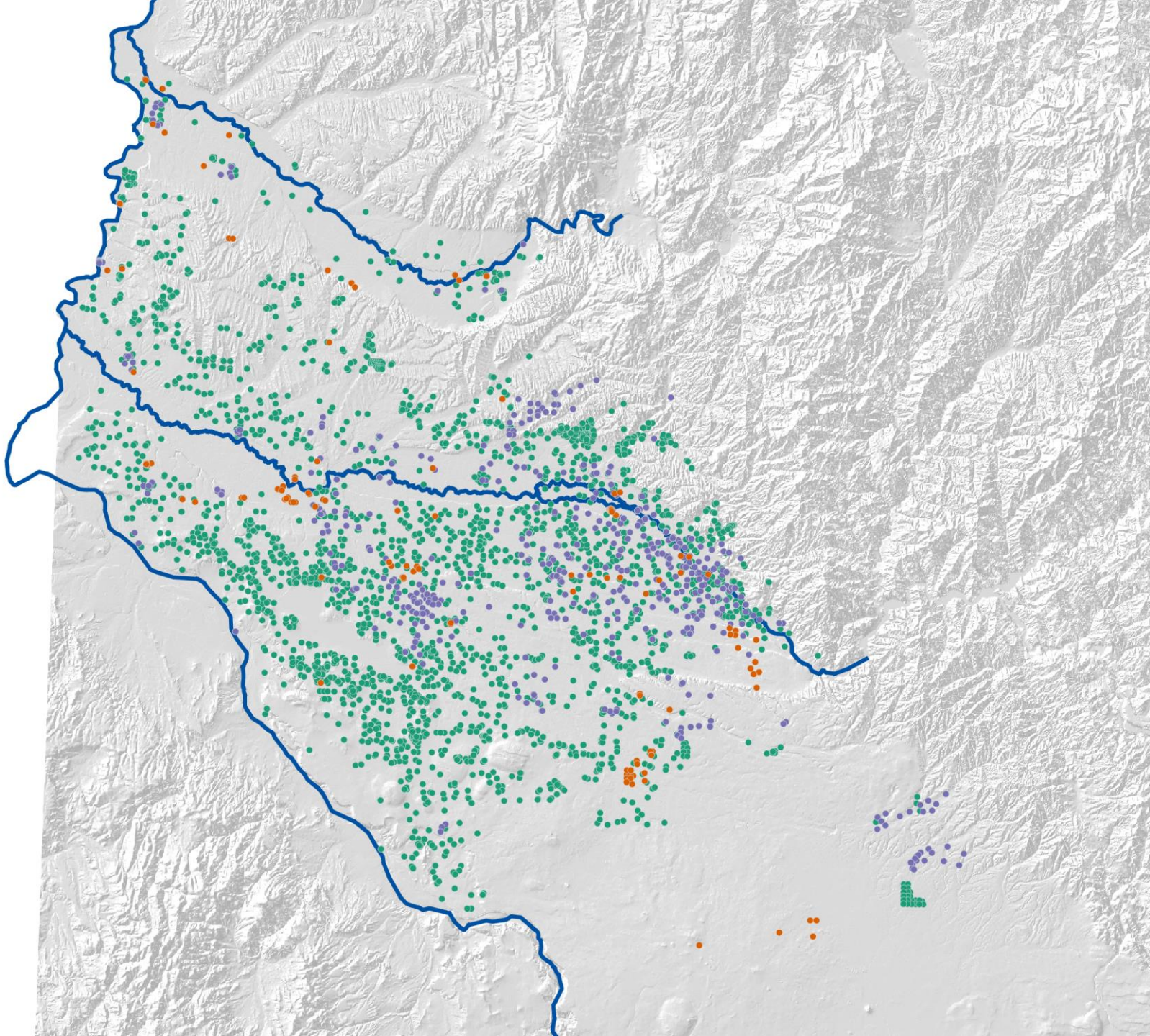
Pumping Wells



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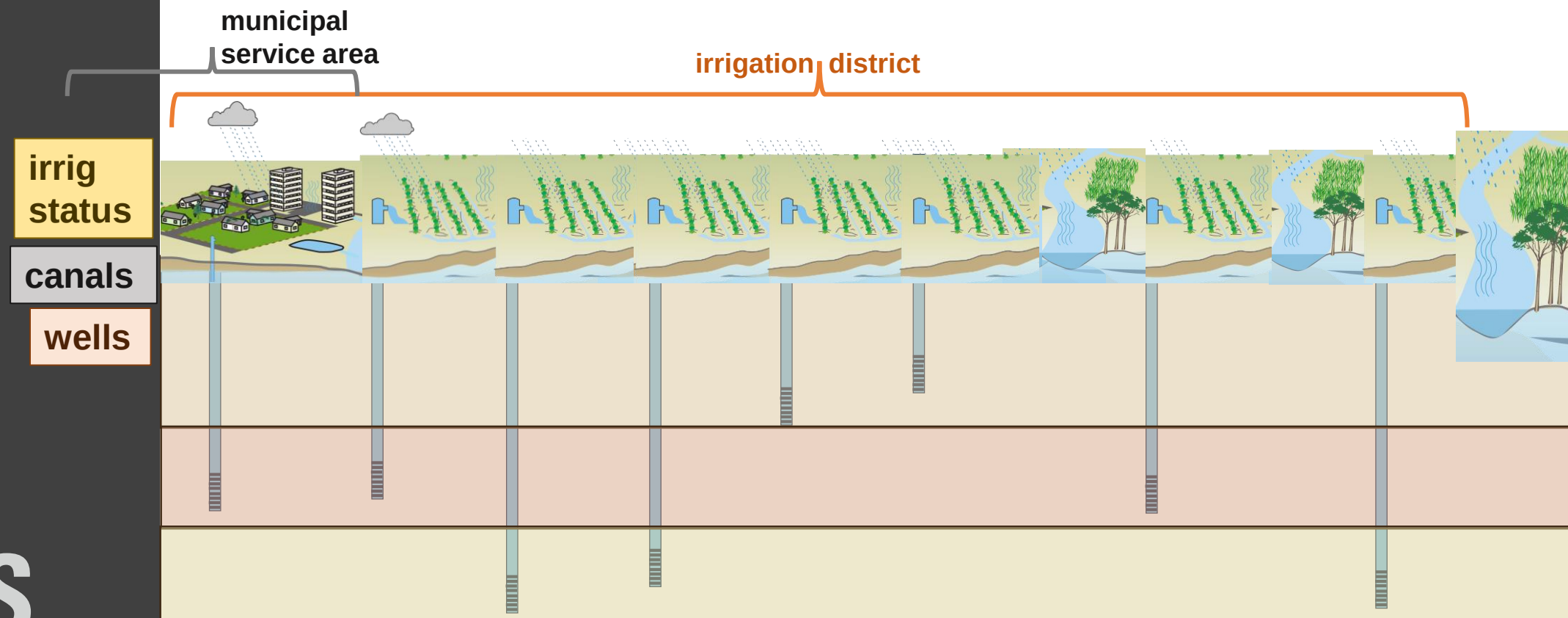
Canal Leakage, Incidental Recharge, & Pumping



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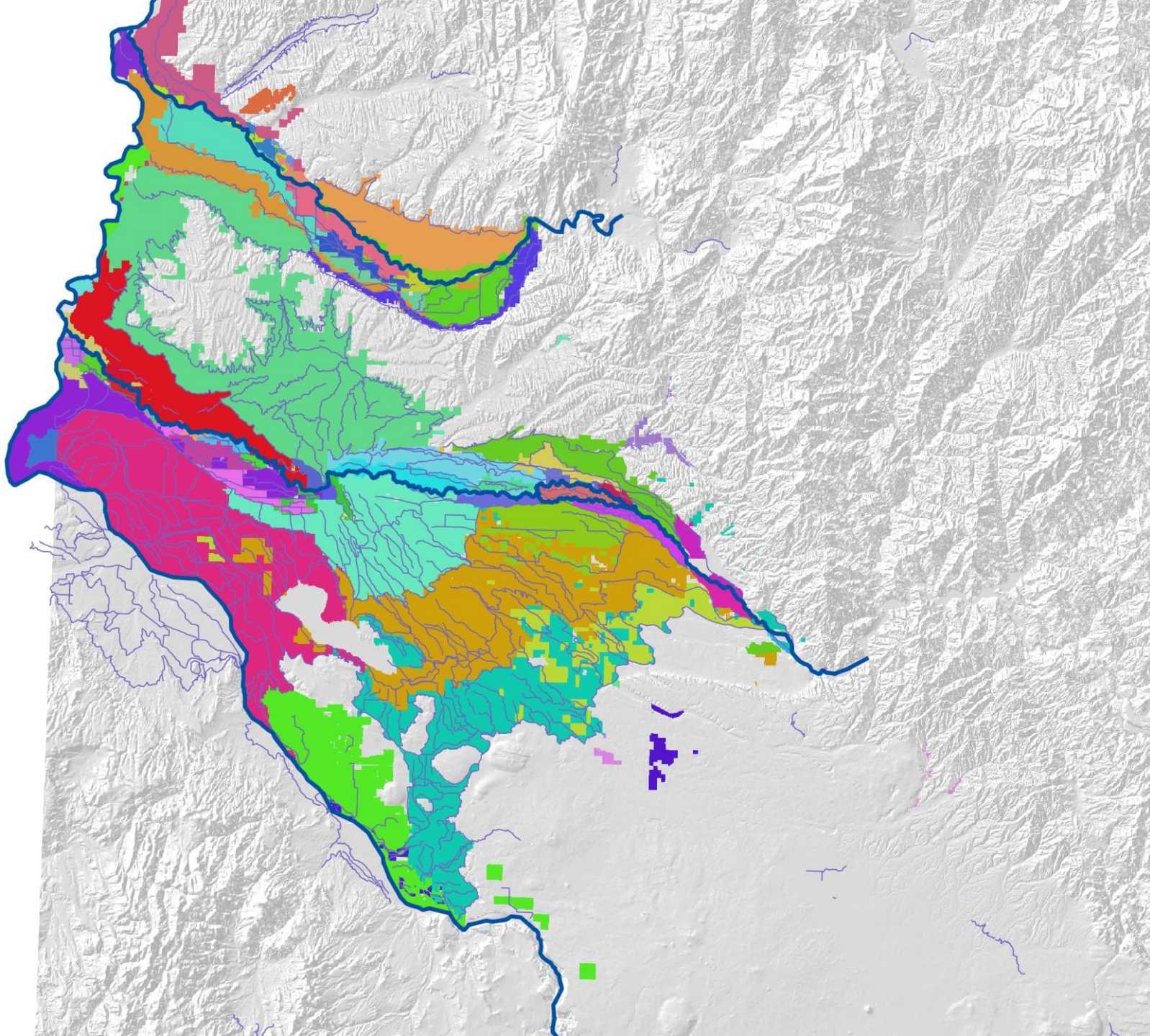
SW Irrigation Distribution



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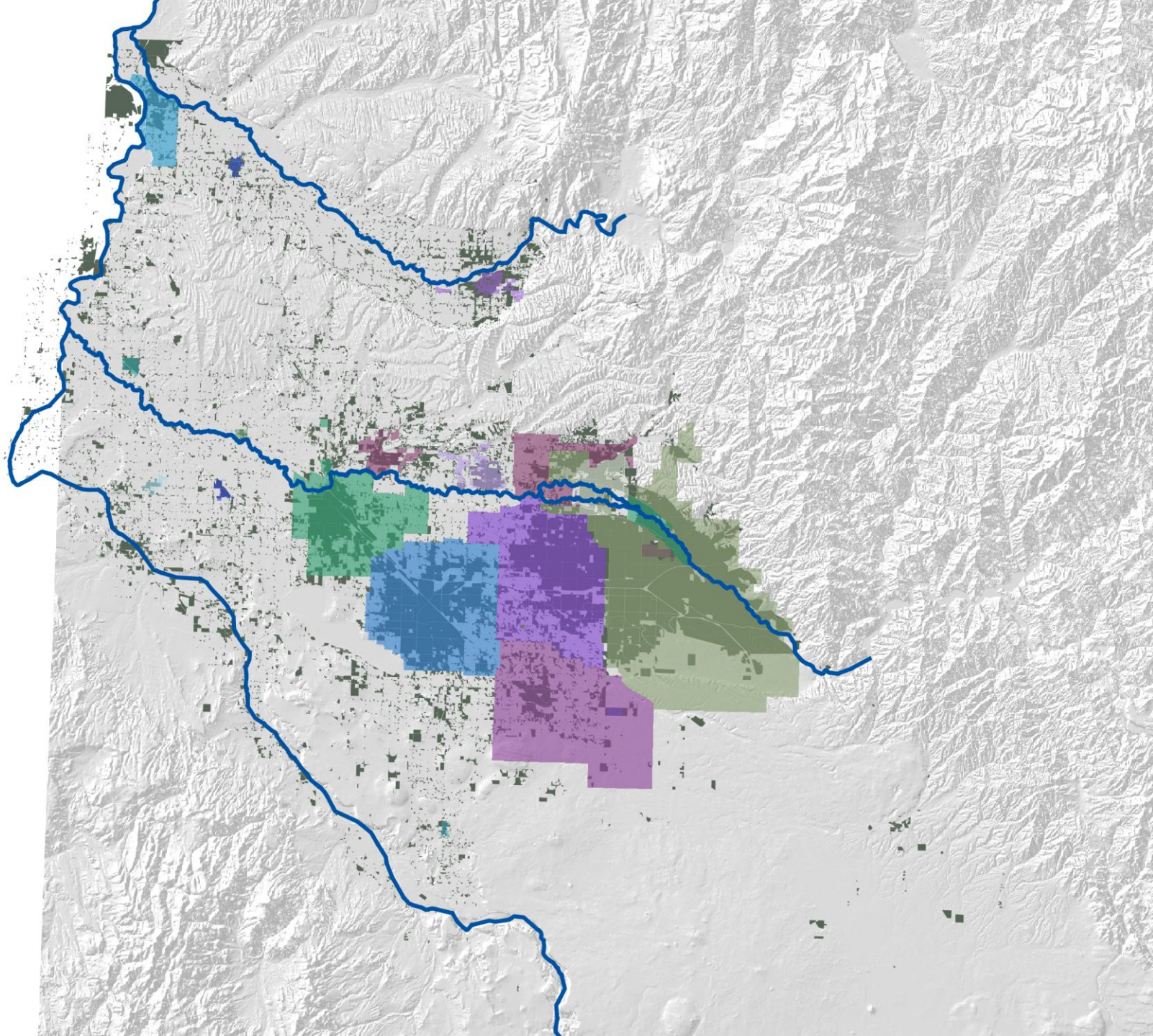
Municipal Deliveries



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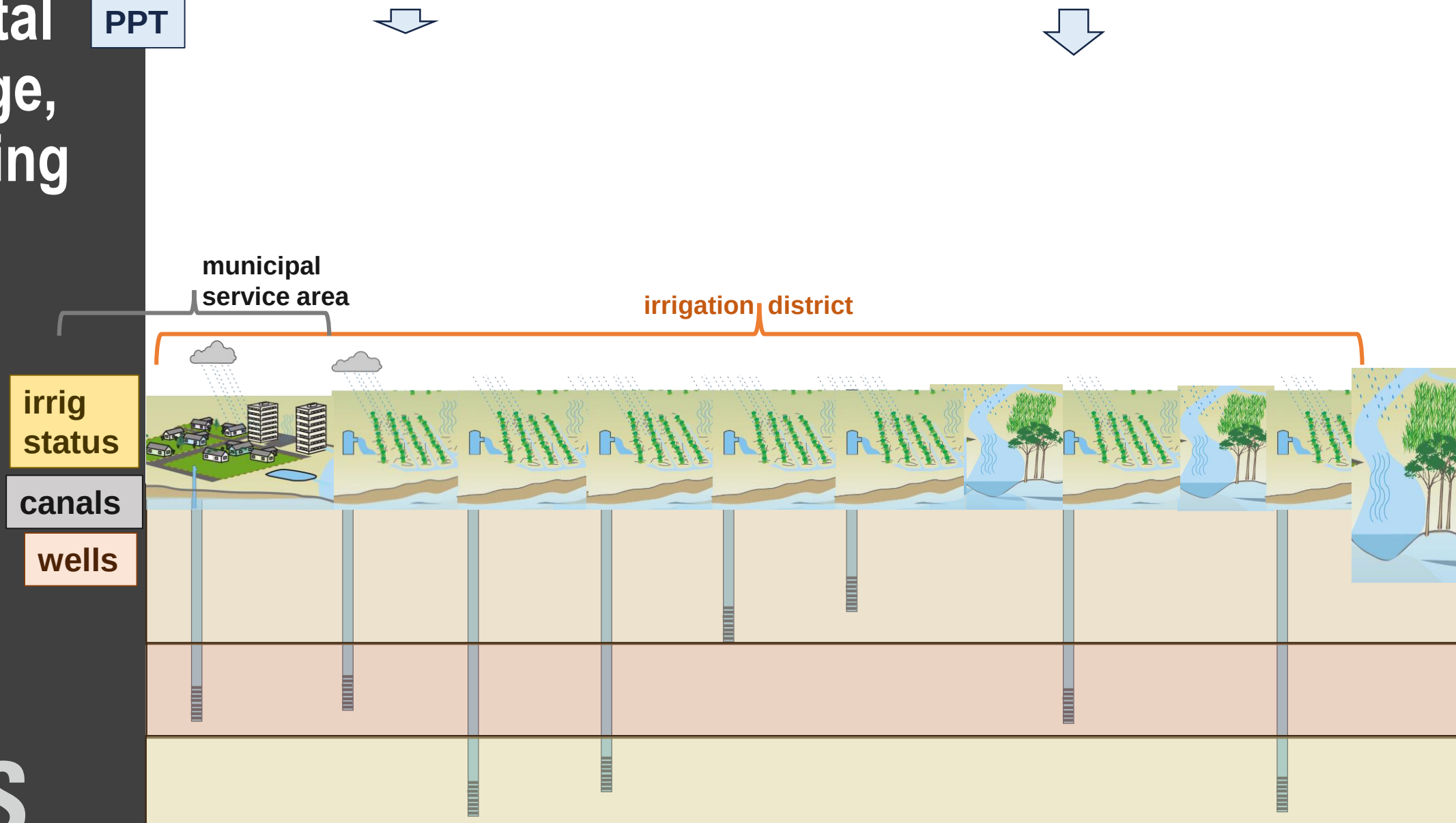
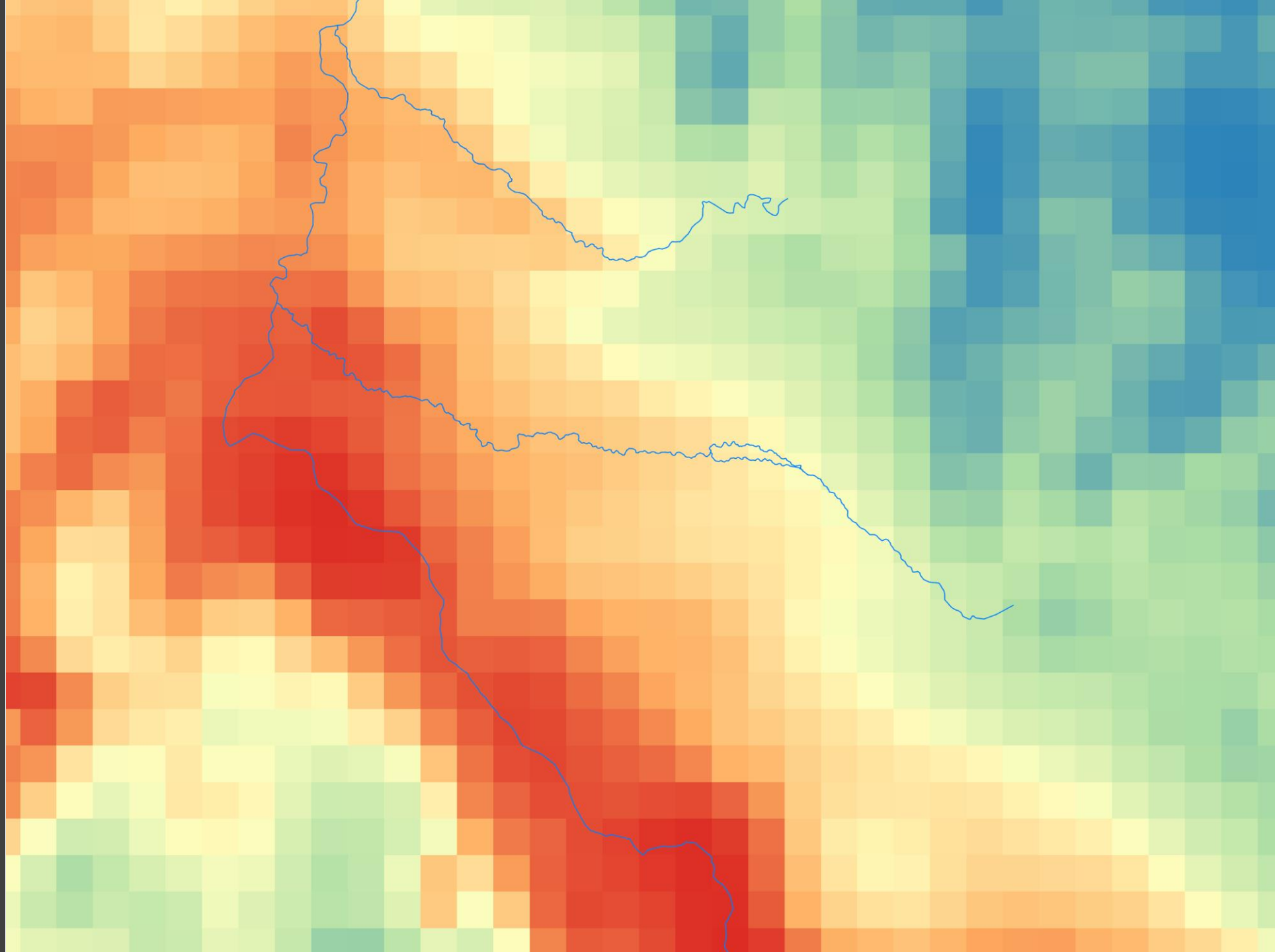
Canal Leakage, Incidental Recharge, & Pumping



Precipitation



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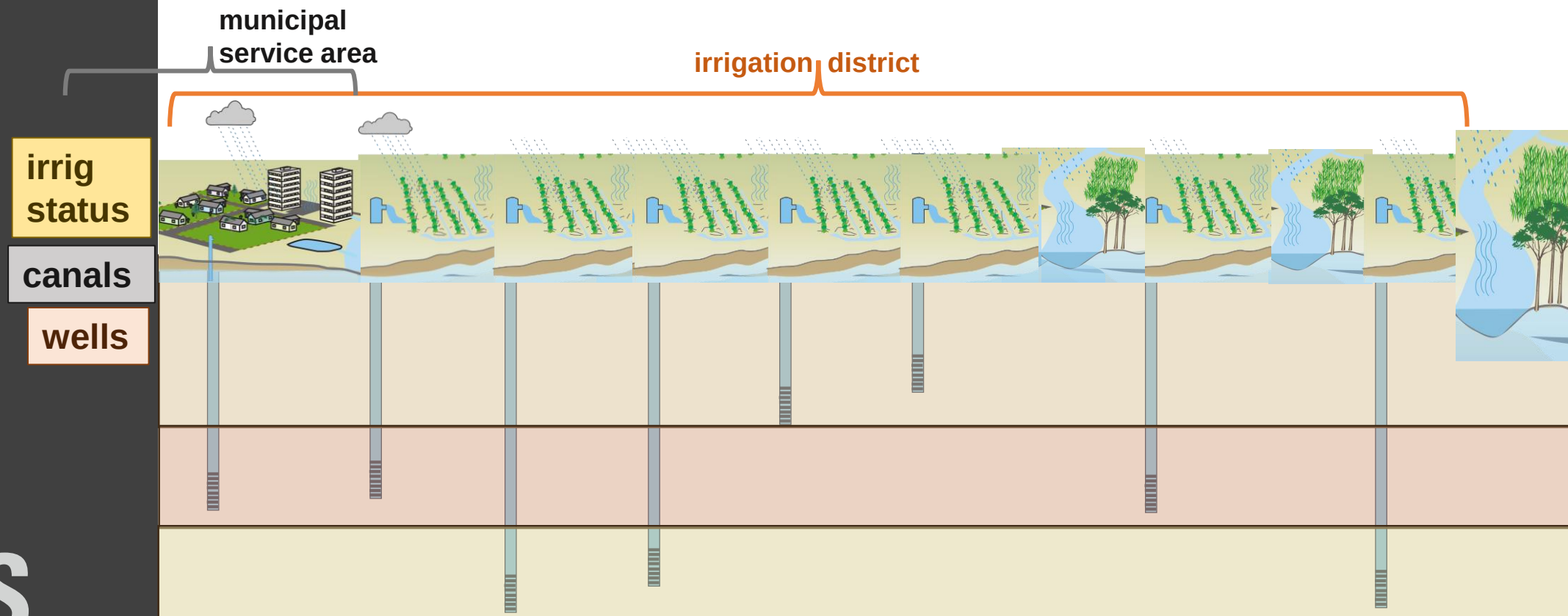
Canal Leakage, Incidental Recharge, & Pumping



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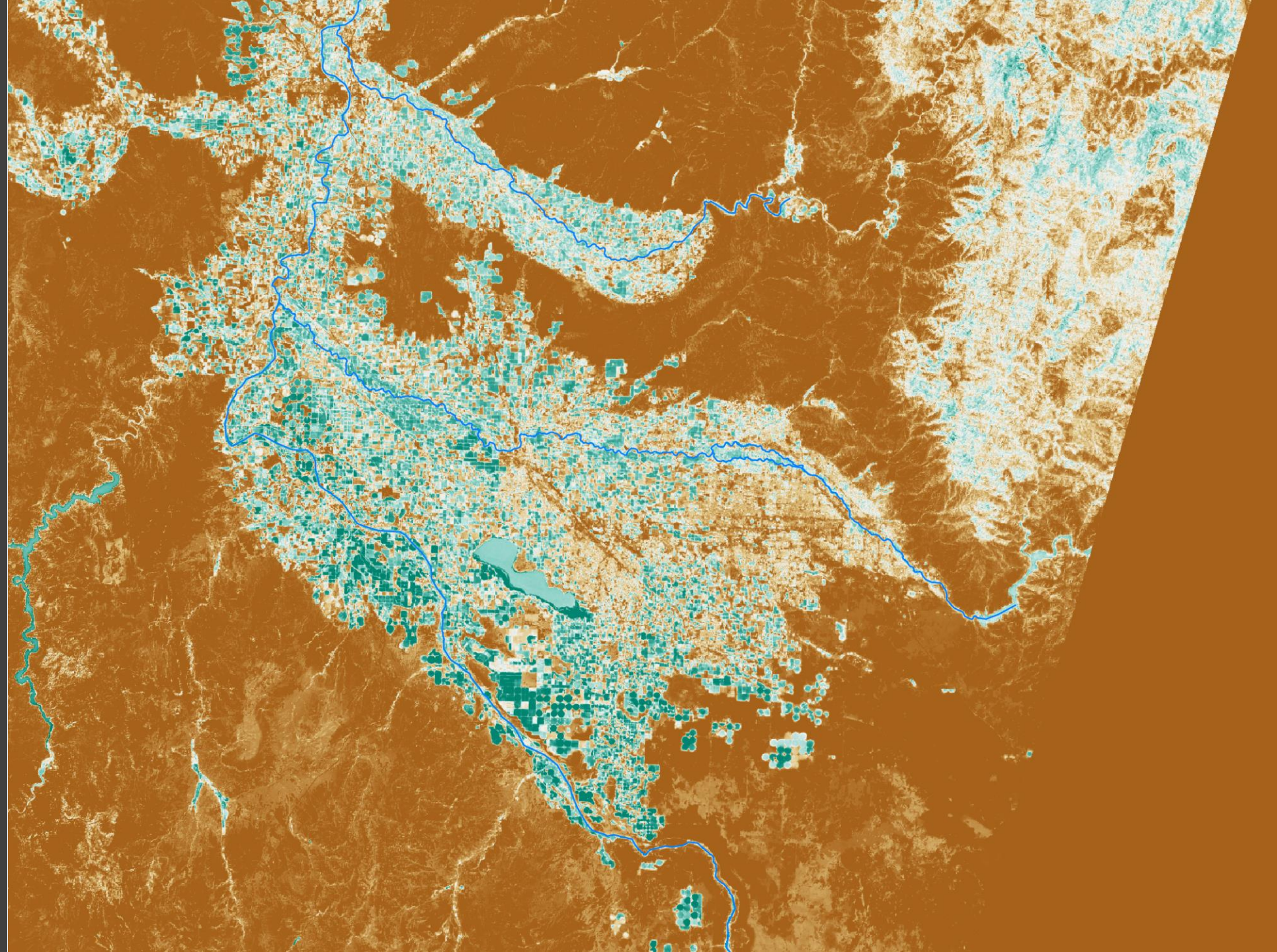
Evapo-transpiration



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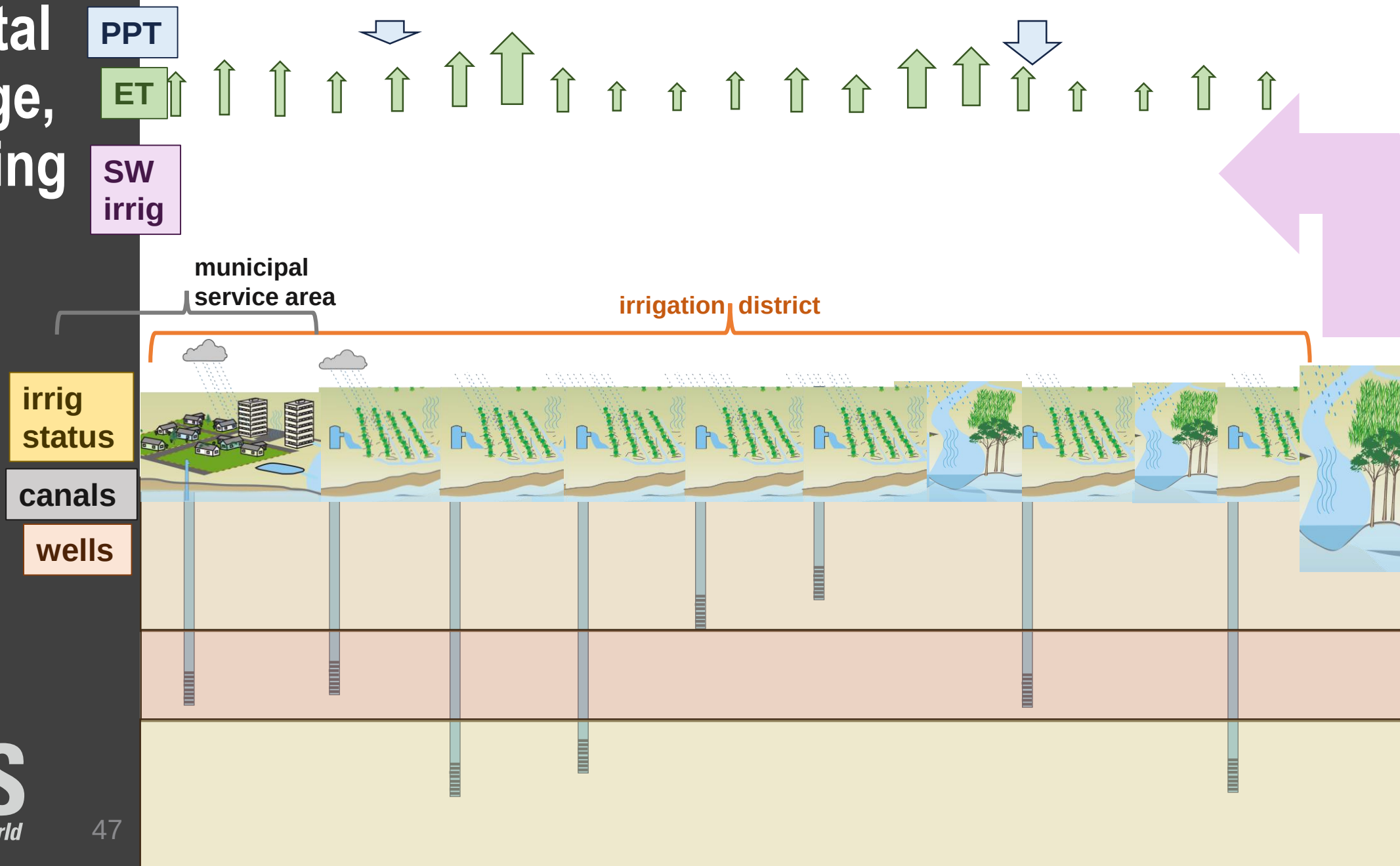
Canal Leakage, Incidental Recharge, & Pumping



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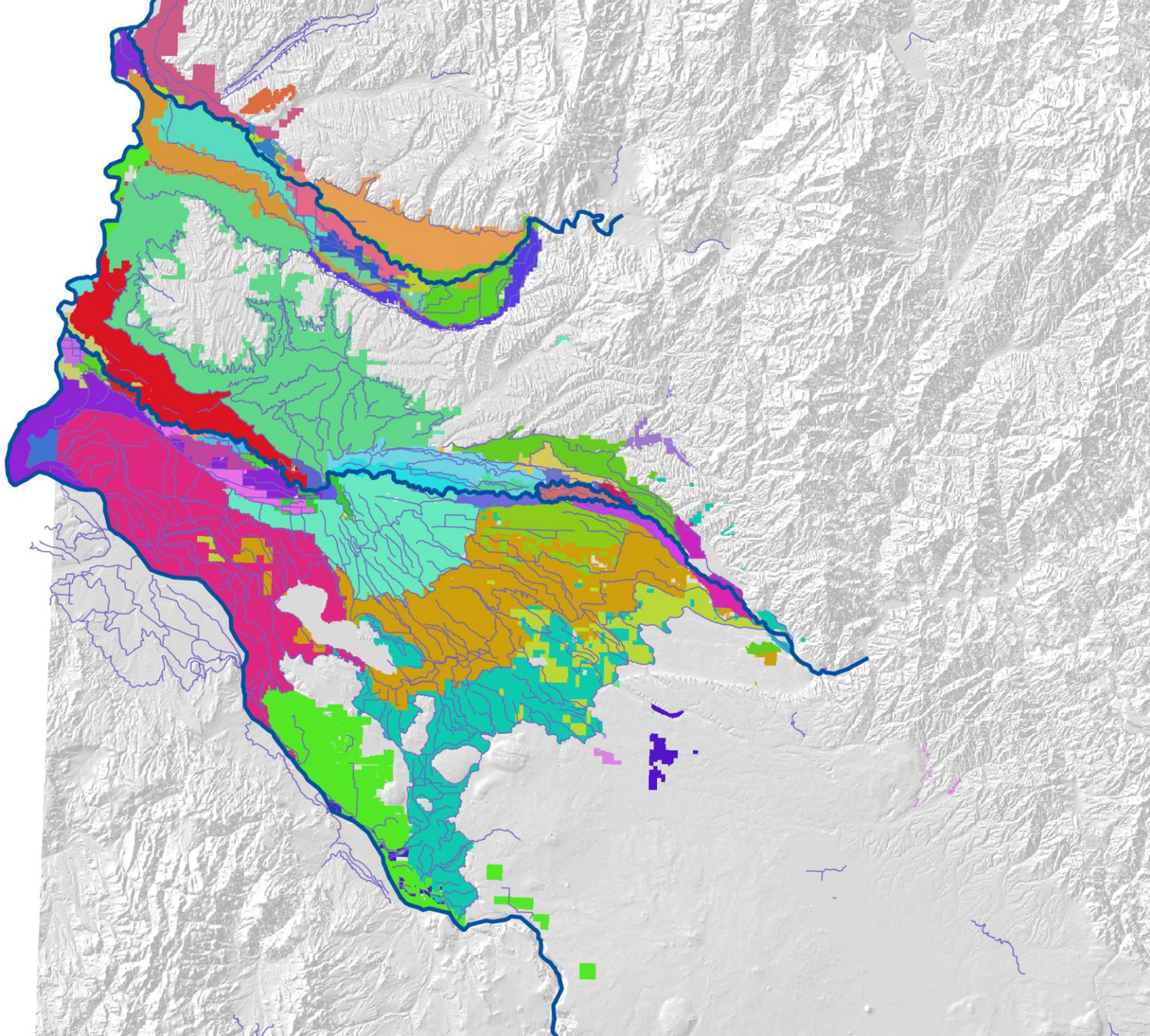
SW Irrigation Distribution



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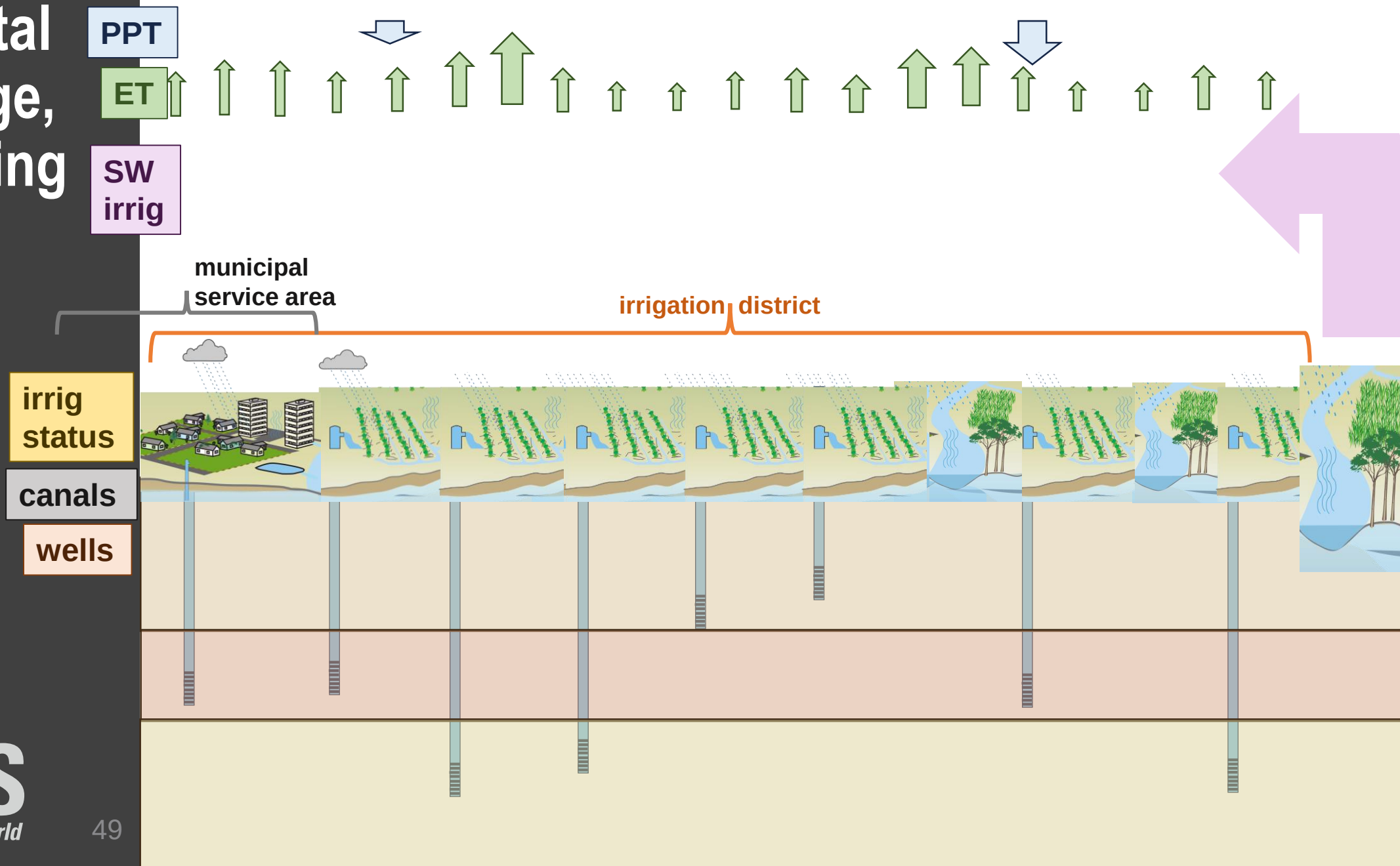
Canal Leakage, Incidental Recharge, & Pumping



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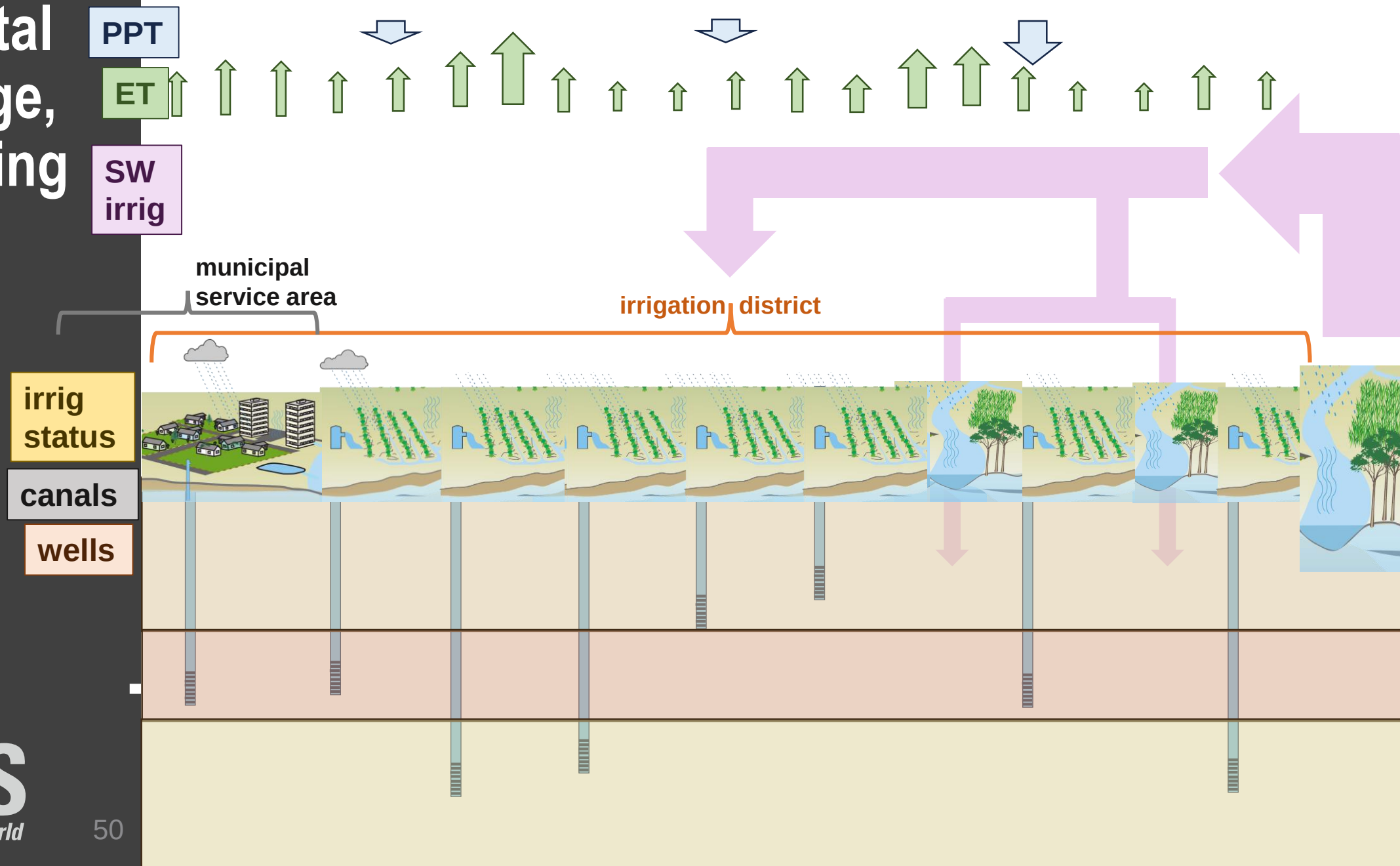
Canal Leakage, Incidental Recharge, & Pumping



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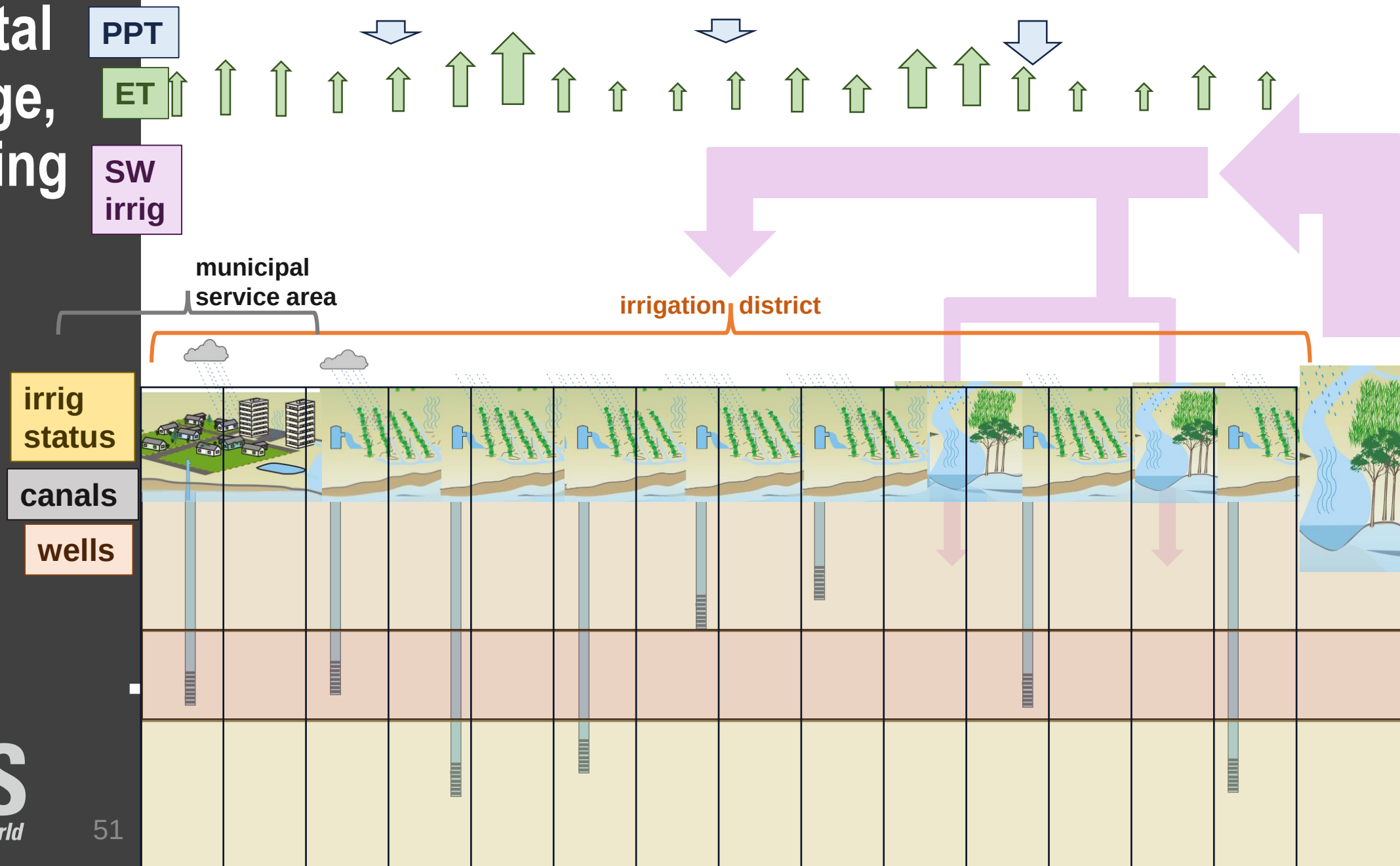
Canal Leakage, Incidental Recharge, & Pumping



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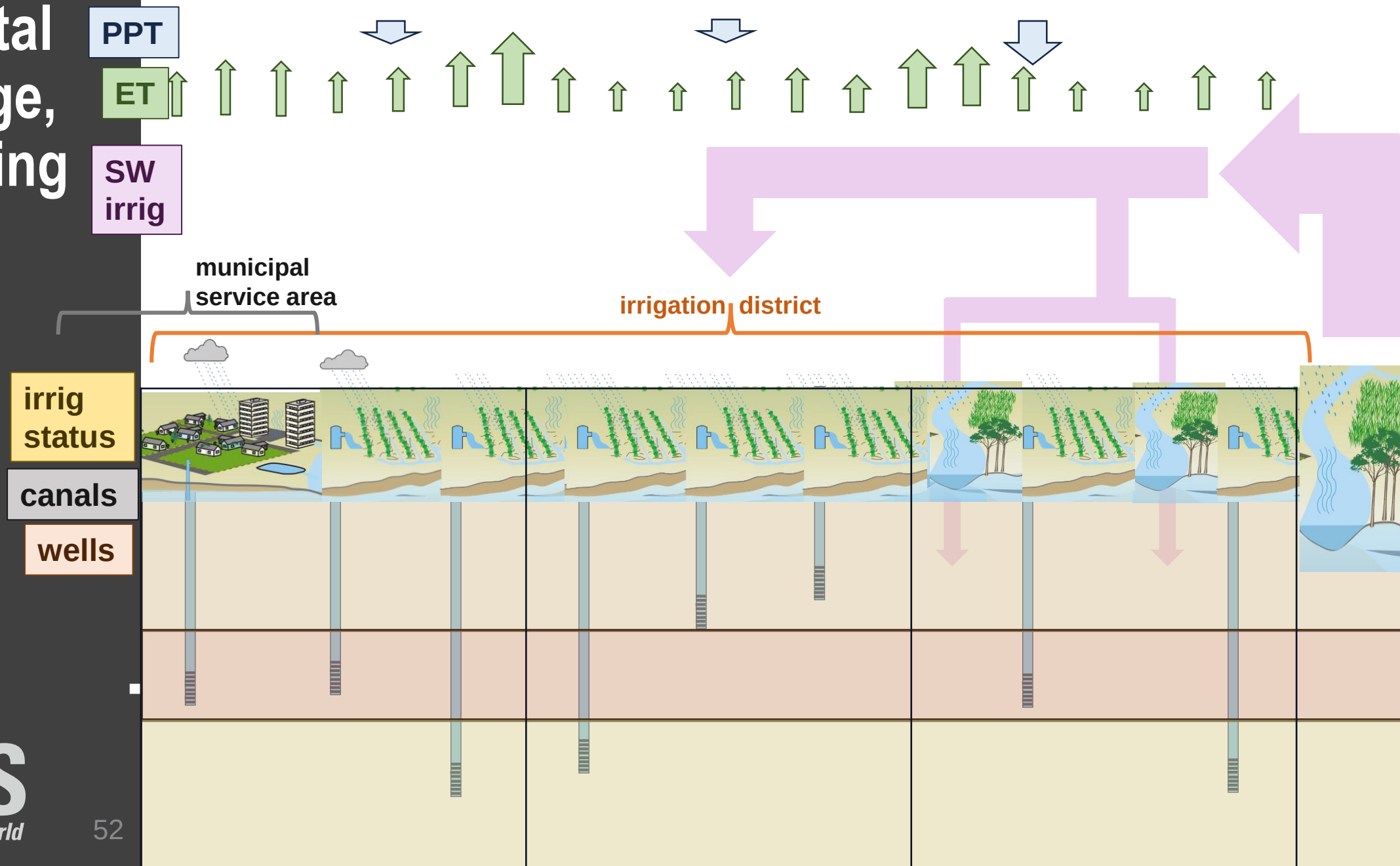
Canal Leakage, Incidental Recharge, & Pumping



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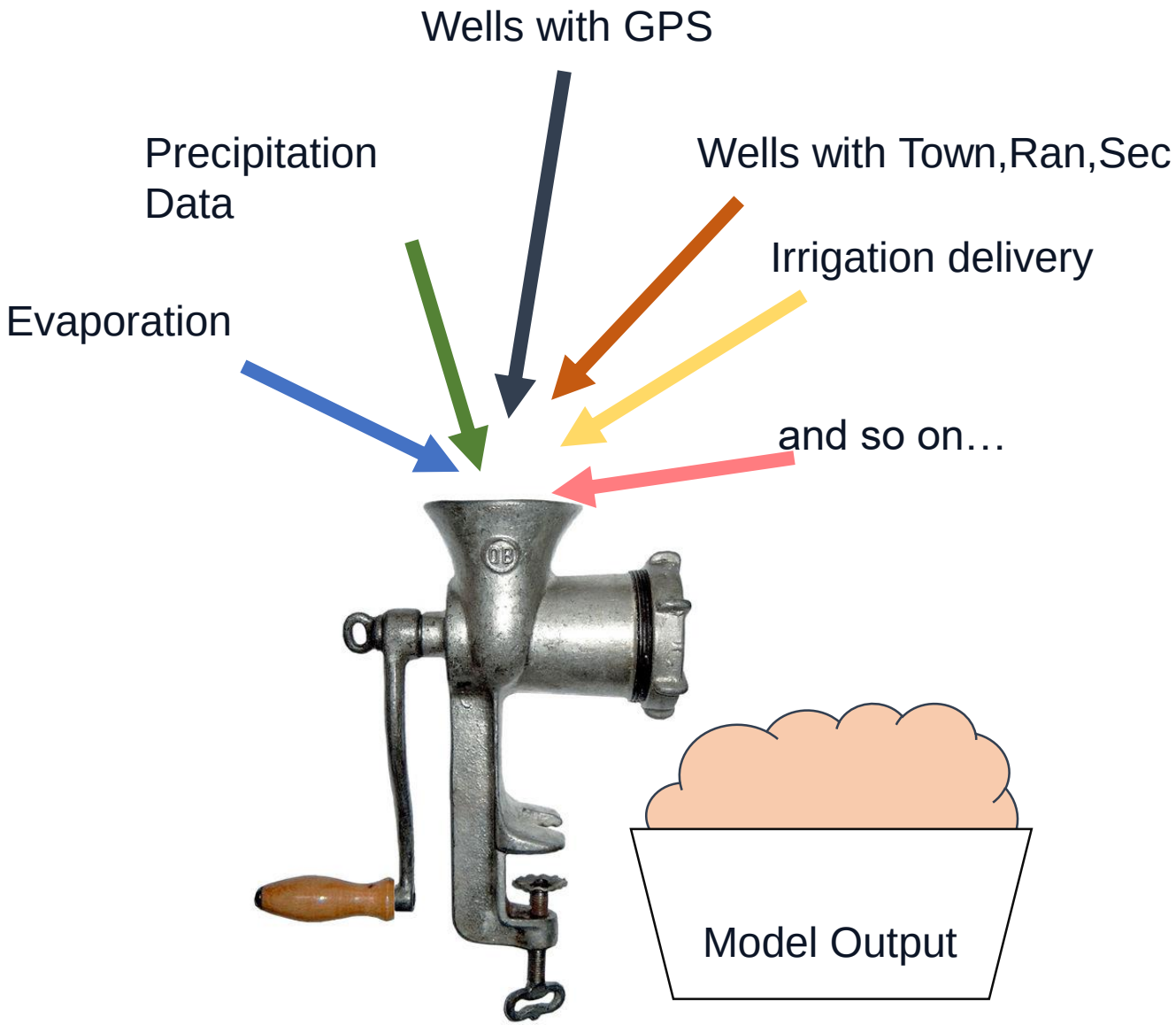
Solution Accuracy

Resolution of model output?

"Model is no better than the data you have to put into it."



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Resolution of model output?

How to evaluate?

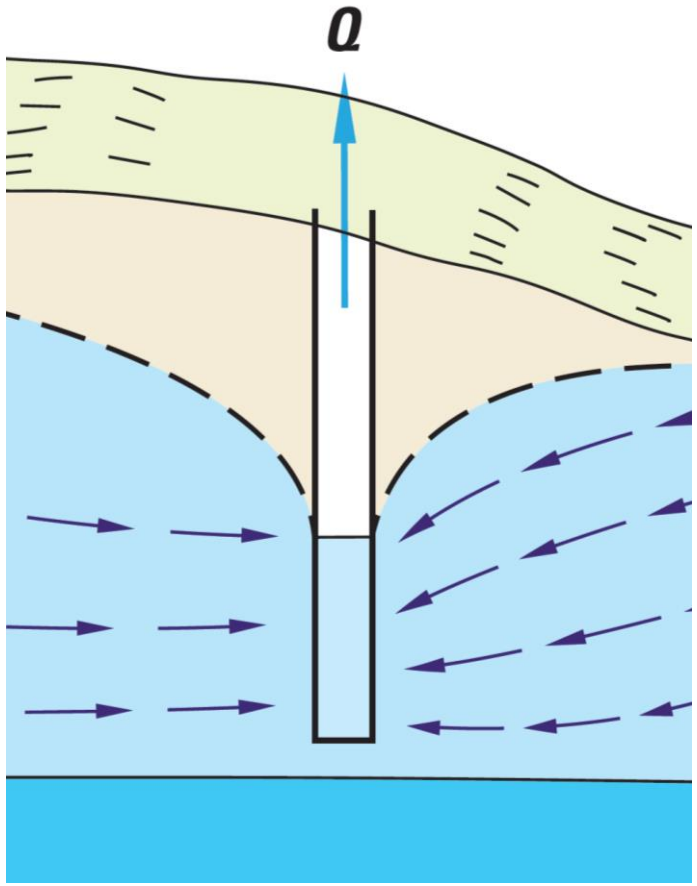
- Select *specific* model outputs of interest.
  - For example, seepage along specific reach of river.

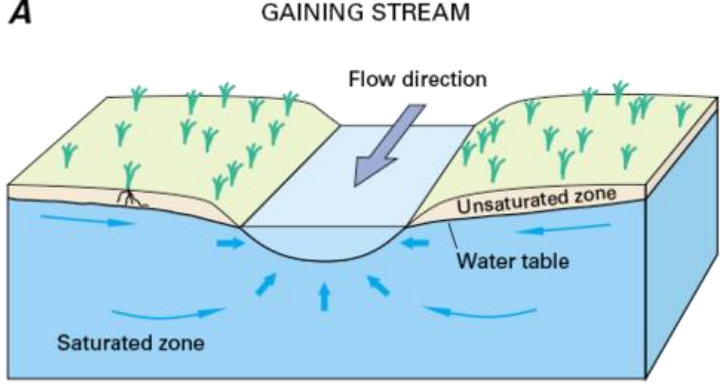
- Sensitivity analysis
  - Possible
  - Need those *specific* outputs of interest

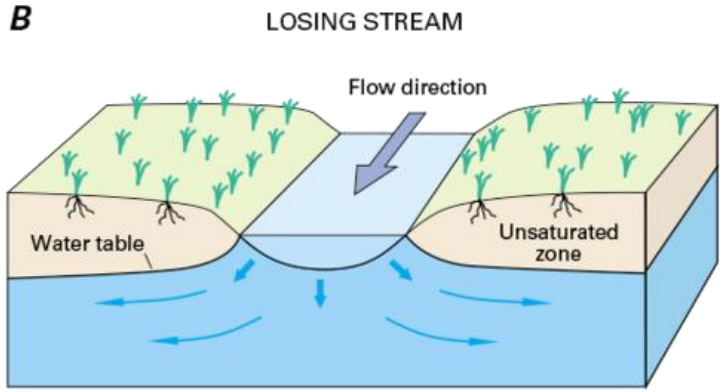
Process Representation

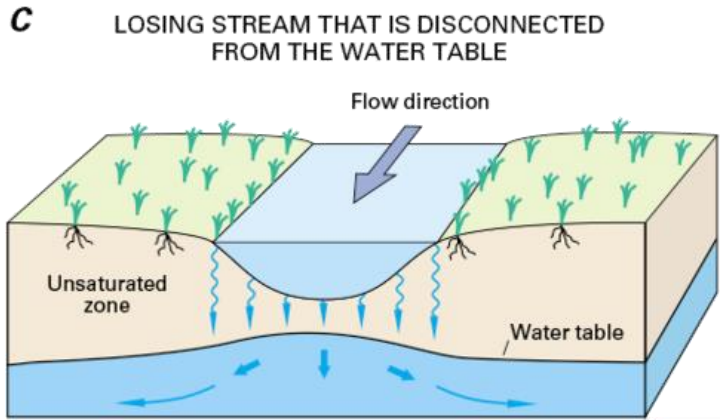
Wells & Rivers

- Boundaries with concentrated stresses









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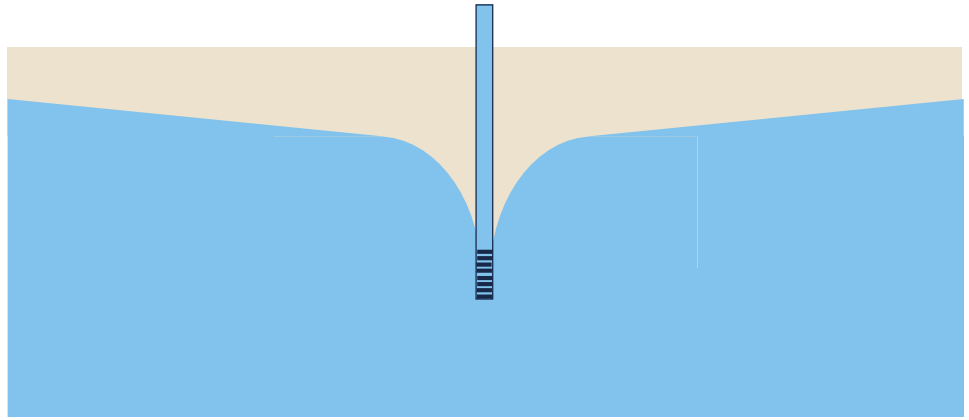
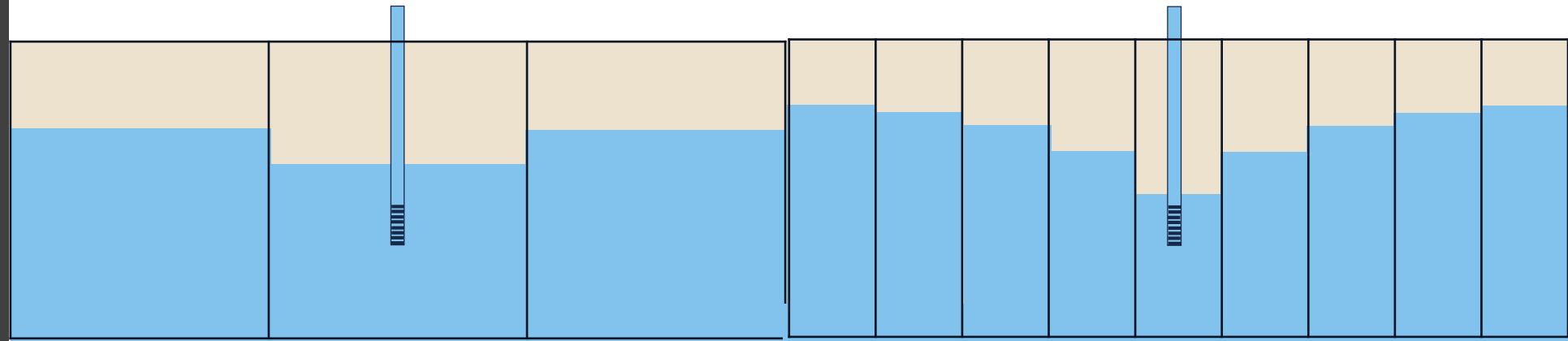
Wells & Rivers

- Boundaries with concentrated stresses

- Effect is spread with greater cell size





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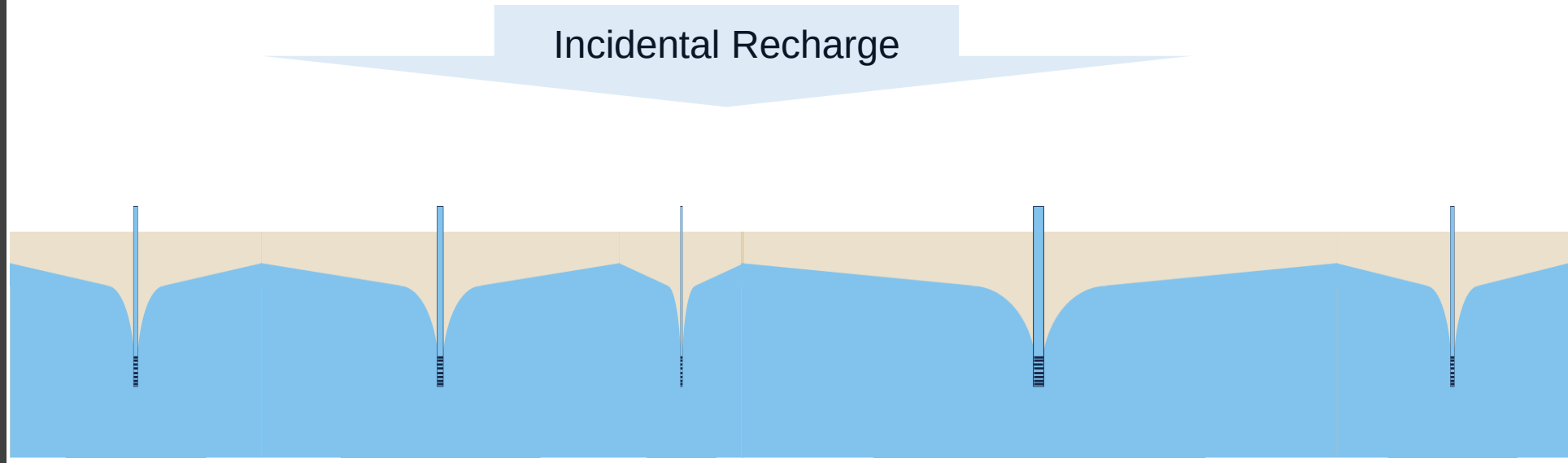
Wells & Rivers

- Boundaries with concentrated stresses

- Effect is spread with greater cell size

- Does this matter for regional questions and combined with important datasets that are regional in scale?



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Runtime

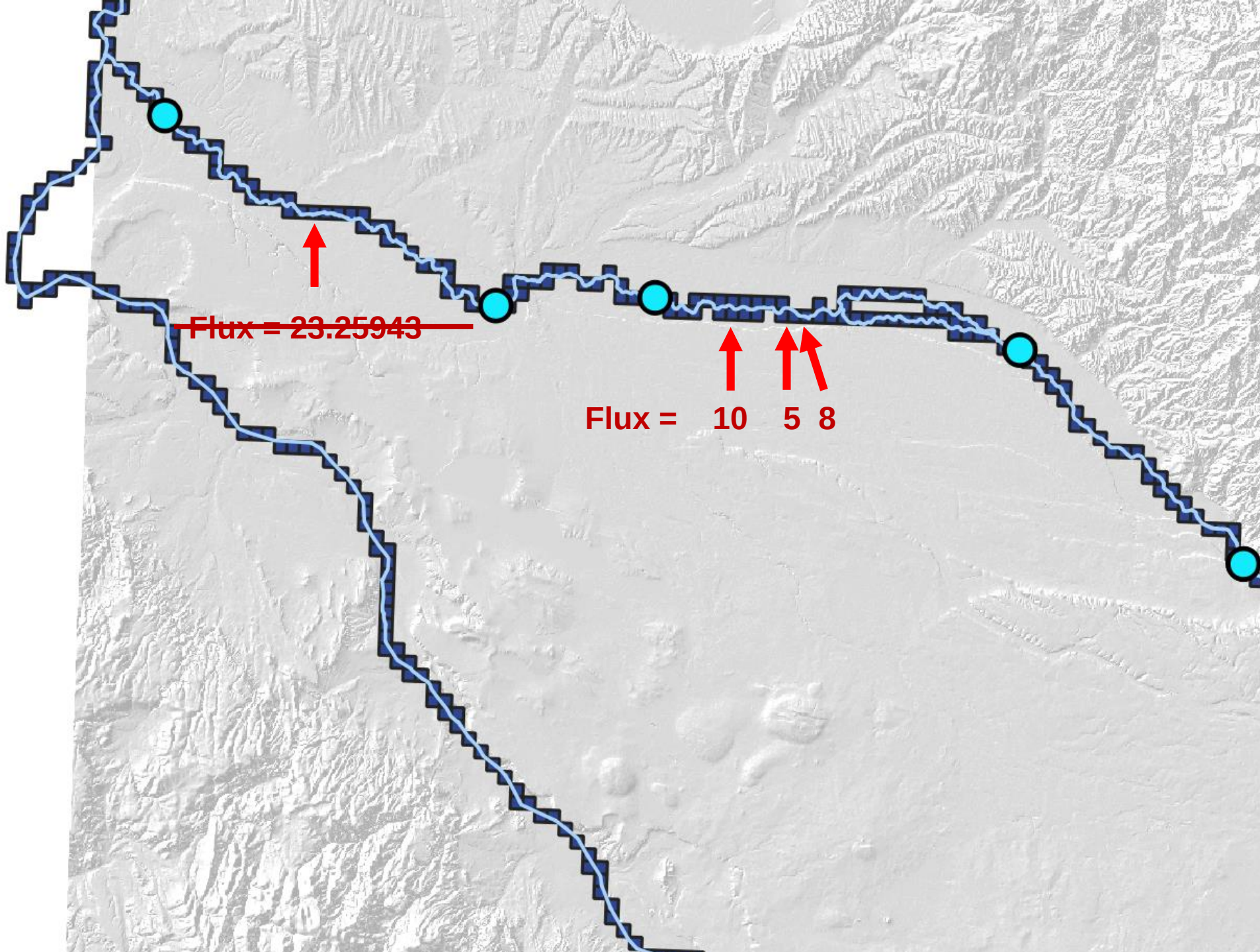
Affects how you can perform important steps:

- Parameterization
- Calibration
- Uncertainty Analysis

```
                                  MODFLOW-2000
    U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUND-WATER FLOW MODEL
                            Version 1.17.01 09/22/2006

 Using NAME file: ..\data\tc1.nam

 Run start date and time (yyyy/mm/dd hh:mm:ss): 2007/01/25 13:58:01

 STARTING VALUES OF REGRESSION PARAMETERS :

   WELLS_TR      RCH_ZONE_1    RCH_ZONE_2    RIVERS        SS_1          HK_1
   VERT_K_CB     SS_2          HK_2

   -1.100         63.07         31.54        1.2000E-03    1.3000E-03    3.0000E-
   1.0000E-07    2.0000E-04    4.0000E-05

   TOTAL SUM OF SQUARED, WEIGHTED RESIDUALS: 0.268E+06

 MODIFIED GAUSS-NEWTON PROCEDURE FOR PARAMETER-ESTIMATION ITERATION NO. =

 VALUES FROM SOLVING THE NORMAL EQUATION :
   MARQUARDT PARAMETER ------------------- =  0.0000
   MAX. FRAC. PAR. CHANGE (TOL= 0.100E-01) = 0.86566
        OCCURRED FOR PARAMETER  "VERT_K_CB " TYPE P

 CALCULATION OF DAMPING PARAMETER
   MAX-CHANGE SPECIFIED:   2.0        USED:   2.0
   OSCILL. CONTROL FACTOR (1, NO EFFECT)-- =  1.0000
   DAMPING PARAMETER (RANGE 0 TO 1) ------ =  1.0000
        CONTROLLED BY PARAMETER "VERT_K_CB " TYPE P

 UPDATED ESTIMATES OF REGRESSION PARAMETERS :

   WELLS_TR      RCH_ZONE_1    RCH_ZONE_2    RIVERS        SS_1          HK_1
   VERT_K_CB     SS_2          HK_2

   -1.001         39.23         43.71        2.1128E-04    1.2206E-03    3.9334E-
   1.8657E-07    8.7307E-05    4.2769E-05

   TOTAL SUM OF SQUARED, WEIGHTED RESIDUALS: 0.112E+04
```

Implied Precision

- Some fields are more disciplined



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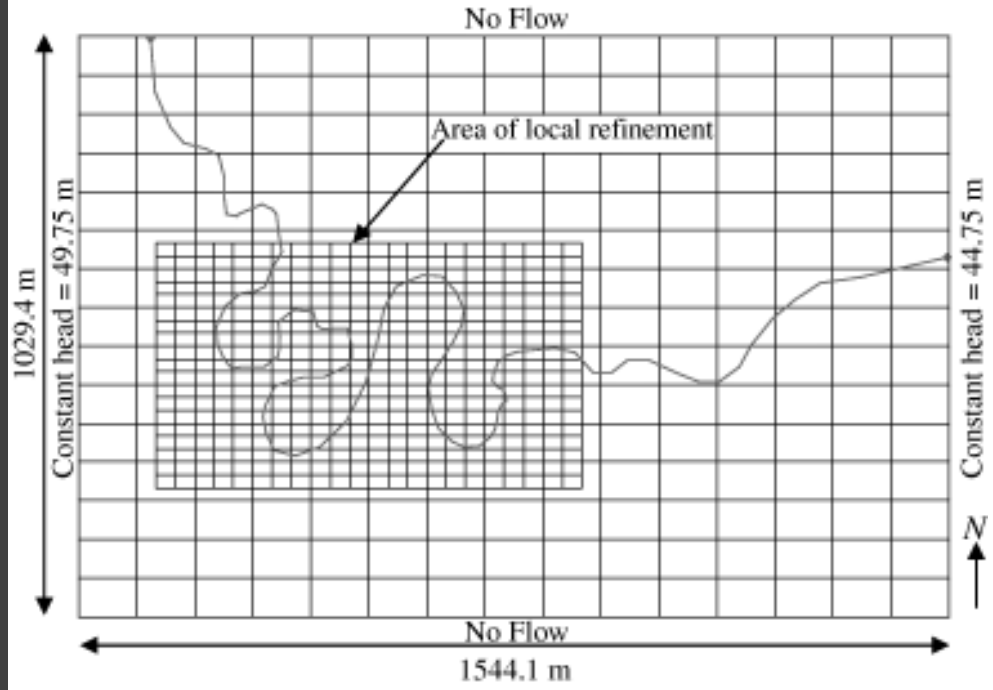
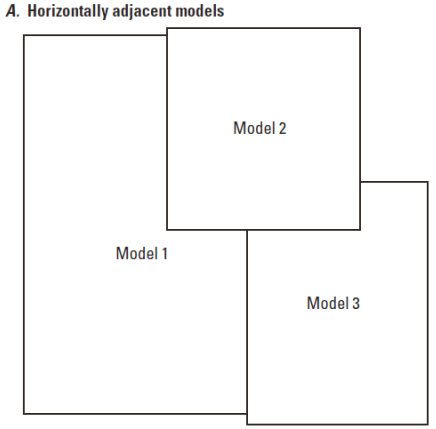
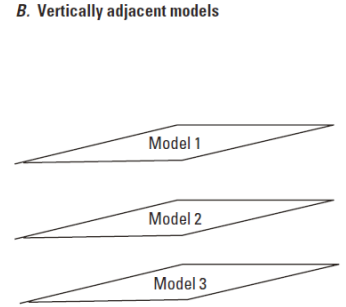
Future Changes

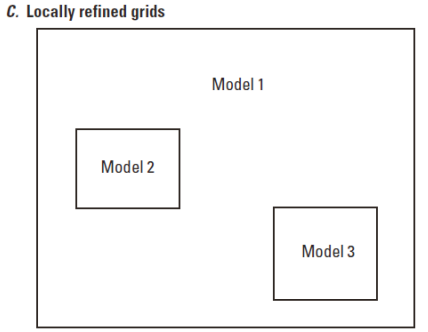
Modflow 6 allows child models or local refinement

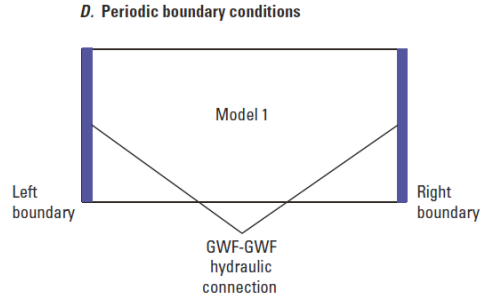
Cell size can be changed in future











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What do we consider?

These are individually difficult to measure

How to weigh tradeoffs without being arbitrary

We are trained to lean towards simplicity

How does grid size affect the precision & accuracy of outputs identified in our model objectives?

- Resolution of input and calibration data
- Solution Accuracy
- Process Representation

Do long runtimes restrict parameterization, calibration, & uncertainty analysis?

- Runtime

Are we inviting misuse?

- Implied precision of model

Is it practical to change model to fit new purposes?

- Flexibility for future uses

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Proposal:

Prepare model to allow for different grid sizes

Develop in 1 mile

Test ½ mile

Compare and present to group

How does grid size affect the precision & accuracy of outputs identified in our model objectives?

- Resolution of input and calibration data
- Solution Accuracy
- Process Representation

Do long runtimes restrict parameterization, calibration, & uncertainty analysis?

- Runtime

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Thanks for listening!

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